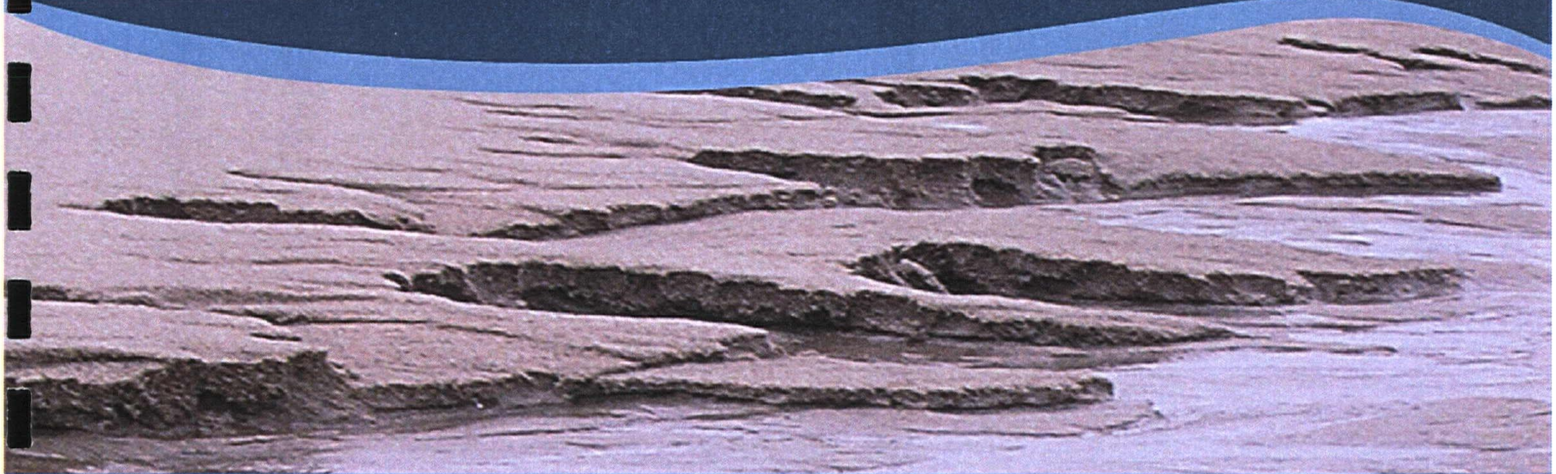
REPORT

ANCHOR QEA



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CLEAN WATER ACT SECTION 404(B)(1) EVALUATION
JORGENSEN FORGE FACILITY

Prepared for
U.S. Environmental Protection Agency,
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

On behalf of
Earle M. Jorgensen Company
10650 South Alameda Street
Lynwood, California 90262

Jorgensen Forge Corporation
8531 East Marginal Way South
Seattle, Washington 98108

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LIST OF ACRONYMS AND ABBREVIATIONS

303(d) list	Washington State Department of Ecology Water Quality 303(d) list
404(b)(1) Evaluation	Clean Water Act Section 404(b)(1) Evaluation
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirements
BA	biological assessment
Boeing	The Boeing Company
Boeing DSOA	Boeing Duwamish Sediment Other Area
BMP	best management practice
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CSL	Cleanup Screening Level
CWA	Clean Water Act
DO	dissolved oxygen
DoC	depth of contamination
DPS	Distinct Population Segment
EAA-4	Early Action Area 4
EE/CA	Engineering Evaluation/Cost Analysis
Ecology	Washington State Department of Ecology
EMJ	Earle M. Jorgensen
EPA	U.S. Environmental Protection Agency
EPP	Environmental Protection Plan
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
Facility	Jorgensen Forge facility located at 8531 East Marginal Way South in Seattle, Washington
FS	Feasibility Study
H:V	horizontal to vertical
LDW	Lower Duwamish Waterway

mg/kg	milligrams per kilogram
MLLW	mean lower low water
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRD	Natural Resource Damage
NTCRA	non-time-critical removal action
OC	organic carbon
O&M	Operations and Maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
RAB	Removal Action Boundary
RAOs	Removal Action Objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
RM	River Mile
RvAL	Removal Action Level
SCER	*Final Source Control Evaluation Report*
SMS	Sediment Management Standards
SMU	Sediment Management Unit
SQS	Sediment Quality Standard
SVOC	semivolatile organic compound
Trustees	Elliott Bay Natural Resource Trustees
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

WDNR	Washington State Department of Natural Resources
WQC	Water Quality Certification
WRIA	Water Resource Inventory Area

1 INTRODUCTION

This Clean Water Act (CWA) Section 404(b)(1) Evaluation (404(b)(1) Evaluation) is an update to the Preliminary Draft CWA Section 404(b)(1) Evaluation, which was Appendix B to the Final Engineering Evaluation/Cost Analysis (EE/CA) and assisted the U.S. Environmental Protection Agency (EPA) in its review of the Final EE/CA removal action alternatives. This version of the document is provided to facilitate EPA's CWA Section 404(b)(1) review and analysis.

On July 10, 2003, Earle M. Jorgensen (EMJ) entered into the Administrative Order on Consent (AOC; EPA Docket No. CERCLA-10-2003-0111 [EPA 2008a]) with the EPA to conduct an investigation to determine whether the Jorgensen Forge facility located at 8531 East Marginal Way South in Seattle, Washington (Facility), is or has been a source of polychlorinated biphenyls (PCBs) to Early Action Area 4 (EAA-4) within the Lower Duwamish Waterway (LDW) adjacent to the Facility. Sampling and analysis conducted by EMJ detected concentrations of PCBs and metals in the sediments and shoreline bank materials within EAA-4 adjacent to the Facility. EPA determined that the detected chemical concentrations within a portion of EAA-4 adjacent to the Facility meet the criteria for initiating a non-time-critical removal action (NTCRA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; EPA 2008a).

For this reason, EPA and EMJ entered into the First Amendment to the AOC (EPA 2008a), which requires EMJ to prepare an EE/CA, a Biological Assessment (BA), and this 404(b)(1) Evaluation to conduct a removal action for affected sediments and associated shoreline bank within the EAA-4 adjacent to a portion of the Facility identified as the Removal Action Boundary (RAB). The RAB is defined by the area where sediment chemical concentrations exceed the Washington State Department of Ecology (Ecology) Sediment Management Standard (SMS) Sediment Quality Standard (SQS) criteria and accounts for a number of site-specific characteristics discussed in Section 4.2.2 of the Final EE/CA. EPA approved the RAB in a letter dated August 8, 2008 (EPA 2008b). In addition, EPA directed the use of the SQS for total PCBs (12 milligrams per kilogram [mg/kg] normalized for organic carbon [OC] content) as the appropriate removal action level (RvAL) for sediment removal and/or capping in the RAB (EPA 2010) to facilitate development of the Final EE/CA prior to completion of the ROD.

EPA issued an Action Memorandum that was received on October 13, 2011, selecting the full removal alternative (Alternative 4 in the Final EE/CA) for the removal action. With issuance of the Action Memorandum, this 404(b)(1) Evaluation document was updated to include relevant information from both the Action Memorandum and the Final EE/CA, including information gathered during ongoing bi-monthly coordination meetings with The Boeing Company (Boeing). Under the Resource Control and Recovery Act (RCRA), Boeing is conducting an interim sediment corrective action in an area adjacent to and north/downstream of the RAB known as the Boeing Duwamish Sediment Other Area (Boeing DSOA), and it is anticipated that the two clean-up actions will occur concurrently so as to minimize disturbances to the aquatic environment and minimize the potential for recontamination.

This 404(b)(1) Evaluation is completed in accordance with the amended AOC for the removal action. The amended AOC (Section II.2) directs that "if dredging, capping, or other filling is a component of any of the alternatives, Respondent shall submit a draft memorandum that provides sufficient information to demonstrate compliance with the substantive requirements of Section 404(b)(1) of the CWA." This 404(b)(1) Evaluation provides information necessary to demonstrate that the proposed removal action technologies and preferred alternative defined in the Final EE/CA are in compliance with the substantive requirements of CWA Section 404(b)(1). Final specific descriptions of the implementation of the selected alternative will be developed during the design phase.

2 PURPOSE AND NEED FOR THE PROPOSED ACTION

The need for the proposed removal action is based on the presence of sediments and shoreline soils adjacent to the Facility that have chemical concentrations above the Ecology's SMS SQS and Cleanup Screening Level (CSL). The SQS represents the concentrations below which there are no adverse effects to biological resources (Washington Administrative Code [WAC]-173-204-300), and the CSL represents the concentrations above which areas of potential concern are defined (WAC 173-204-520). As part of the development of the *Final Source Control Evaluation Report* (SCER; Anchor and Farallon 2008), surface sediment concentrations were evaluated in the sediments adjacent to the Facility. Results indicated that specific areas contain surface sediment with PCBs, metals, and semivolatile organic compound (SVOC) concentrations above the SQS and CSL criteria.

The purpose of the proposed action is to remediate impacted sediments to reduce ecological and human health risks to acceptable levels. EPA has approved the recommended removal action alternative (Alternative 4) proposed in the EE/CA. This removal action alternative addresses nearshore and offshore impacted sediment that is located within potentially jurisdictional waters and therefore, the sediment remediation is a water-dependent activity (40 CFR § 230.10).

The RAB is within a working harbor with ongoing industrial activities and contains a federally maintained navigation channel, which allows transit of large ships into the active harbor. Much of the LDW shoreline contains overwater piers and berths, port terminals and slips, and other engineered features; armoring covers approximately half of the harbor shoreline, which is integral to the operation of industrial activities in the LDW. The City of Seattle's long-range goal is to promote economic growth and support manufacturing and industrial activity in the LDW as indicated in the Greater Duwamish Manufacturing and Industrial Center Plan (City of Seattle 2000). Much of the improved shoreline is integral to achieving these objectives. Thus, the proposed removal action must achieve the project purpose (i.e., sediment remediation consistent with the criteria established through the CERCLA process) in a manner that is consistent with the current and future maritime and industrial uses of the LDW and minimizes temporary disruptions of these activities.

3 DESCRIPTION OF THE PROPOSED ACTION

3.1 Location

The removal action will address sediments and the associated shoreline bank within the EAA-4 adjacent to the Facility on the eastern shoreline of the LDW, at approximately River Mile (RM) 3.6 (Figure 1). The project is proposed to occur within the EPA's LDW Superfund Site. The Superfund Site extends from the mouth of the LDW to approximately RM 5, approximately 1.4 miles upriver from the Facility.

The setting of the LDW is heavily industrialized and the river shoreline is significantly modified throughout most of its length—especially within the first 5 miles inland from the mouth of the LDW, along the length containing the federally maintained navigation channel. The Duwamish River was historically an estuary that supported many fish and wildlife species, and remains an important migration corridor for several salmonid species listed under the Endangered Species Act (ESA). The LDW is a transitional zone where anadromous fish migrate from freshwater streams to the ocean. Existing habitat conditions within the LDW migration corridor are degraded as the shoreline is highly modified. Some recreational and/or subsistence fishing, and other recreational activities occur to a limited extent in the vicinity of the RAB. No residential areas are located adjacent to the RAB, although residential neighborhoods are located in the uplands approximately 1000 feet from the opposite shoreline (generally to the west of the RAB).

3.2 Description of the discharge and fill sites

The RAB is a project boundary for the proposed removal action and includes the geographic area relevant to the project shown in Figure 2; it is bounded by the following:

- To the north/downstream by the in-water and shoreline bank sediment cleanup boundaries identified in the EPA-approved Memorandum of Understanding (MOU; EMJ et al. 2007)
- To the west by the federal navigation channel, as well as a small 20-foot extension into the channel in one location adjacent to sediment sampling station SD-DUW322
- To the south by the extension of the southern Facility property boundary into the LDW
- To the east by the top of the shoreline bank slope along the central and northern

portions of the Facility and the top of the sheetpile and abutted concrete panel wall on the southern portion of the Facility

The shoreline area within the northern and central portion of the RAB is steep and heavily armored with scattered remnant pilings from a former railroad trestle. Mudflats are present at low tide, below upper bank riprap and miscellaneous armoring (Windward 2003). The southern shoreline area is abutted by a vertical sheetpile wall joined to a concrete panel bulkhead and contains three permitted stormwater outfalls that discharge to the LDW. Elevations within the RAB range from intertidal zone from the top of bank (approximately 19 feet mean lower low water [MLLW]) to subtidal (-14 feet MLLW). There are no aquatic land uses along the shoreline.

The RAB has been divided into 11 Sediment Management Units (SMU) based on an initial evaluation of sediment chemistry and operational/engineering considerations. Four alternatives, including three action alternatives and one No Action Alternative, were carried through the EE/CA alternatives evaluation based on chosen cleanup alternatives within each of 11 SMUs. The removal action alternatives considered in the EE/CA are shown on Figures 3, 4, and 5, and are described in more detail in the following subsections.

3.3 Summary of Alternatives

The alternatives presented in the EE/CA consist of the No Action Alternative (Alternative 1) and three action alternatives that would include various combinations of slope excavation and containment, capping, dredging and backfill, and disposal into a Subtitle D permitted offsite landfill facility (Subtitle D landfill).

Under Alternative 1, no action would be undertaken and the Facility would remain in its current state, with no removal actions implemented. Alternatives 2 and 3 would consist of slope excavation and containment, variable dredging followed by capping/backfill, capping without dredging, and Subtitle D landfill disposal. Alternative 3 differs from Alternative 2 in that it includes more extensive dredging. Alternative 4 requires that all in-water sediments with concentrations greater than the total PCB RvAL would be removed from the RAB. In Alternatives 3 and 4, removal adjacent to the sheet pile wall and concrete panel walls would be offset from the wall by 5 feet to minimize potential impacts to the structural stability of the walls.

Each alternative is described in detail in the Final EE/CA, and summarized in Table 1 by SMU and remedy.

Table 1
Summary of Removal Action Alternatives

Alternative	Bank reconfiguration followed by containment	Dredging (approximate depths) and backfill	Sediment Capping
Alternative 1 (No Action)	None	None	None
Alternative 2	4-foot slope containment in SMU-3, SMU-5, SMU-8, and SMU-11	• 2-foot removal and 2-foot backfill SMU-7 and SMU-10 • 4-foot removal and 4-foot backfill in SMU-6 • 8-foot removal and 6-foot backfill in SMU-4B	• 2-foot cap in SMU-1A and SMU-1B • 4-foot removal and 4-foot cap with adjustments for navigation in SMU-2 • 4-foot removal and 4-foot backfill in SMU-4A, SMU-4C, and SMU-9
Alternative 3	4-foot slope containment in SMU-3, SMU-5, SMU-8, and SMU-11	• 1-foot removal and 1-foot backfill SMU-1A • 2-foot removal and 2-foot backfill SMU-7, SMU-10 • 4-foot removal and 4-foot backfill in SMU-6 • 8-foot removal and 6-foot backfill in SMU-4B	• 4-foot removal and 4-foot cap in SMU-1B • 4-foot removal and 4-foot cap with adjustments for navigation in SMU-2 • 4-foot removal and 4-foot cap in SMU-4A, SMU-4C, and SMU-9
Alternative 4	4-foot slope containment in SMU-3, SMU-5, SMU-8, and SMU-11	• 1-foot removal and 1-foot backfill SMU-1A • 5.5-foot removal and 5.5-foot backfill in SMU-1B, SMU-4A, and SMU-9 • 10.5-foot removal and 10.5-foot backfill SMU-2 • 8-foot removal and 6 feet of backfill SMU-4B • 9.5-foot dredge cut and 9.5-foot backfill SMU-4C • 4-foot removal and 4-foot backfill in SMU-6 • 2-foot removal and 2-foot backfill SMU-7 and SMU-1	None

3.4 Additional Actions under Proposed Alternatives

Additional activities that may potentially occur concurrent with the removal action include construction of a restoration project as part of the EMJ and Jorgensen Forge Natural Resource Damage Assessment (NRDA) settlement with the Elliott Bay Natural Resource Trustees (Trustees), excavation to remove contaminated soils and corrugated metal pipe at the discharge of the inactive property line outfalls located along the Boeing Plant 2 and Facility property lines, and improvements to the existing Facility stormwater discharge structures.

Technical analyses and agency negotiations are currently being conducted for each of these activities to determine a path forward for inclusion as elements of the overall sediment and shoreline bank cleanup of the Facility. As these final analyses and negotiations are completed and design plans are further developed for these activities, an addendum to the 404(b)(1) Evaluation will be prepared and provided to EPA.

Additionally, the removal action will require extraction of approximately 40 treated wood piling from within the RAB prior to construction. The removal of the piling is not considered a discharge of dredged or fill material and is not addressed further in this Section 404(b)(1) analysis. The removal of piling will be conducted according to the best management practices (BMPs) identified for piling removal in the BA for this project (Anchor QEA 2011b). This action is expected to improve the condition of the LDW through removal of a source of contaminants (i.e. creosote).

3.5 Removal Action Alternative Technologies

The three action alternatives considered in the EE/CA include one or more of the following technologies:

1. Bank excavation and placement of slope containment materials
2. Backfill and/or armored (engineered) capping
3. Dredging

Each of these technologies and their application under specific alternatives are discussed, along with construction methods, in the following subsections.

3.5.1 Bank Excavation and Slope Capping

Each of the active alternatives (2, 3, and 4) includes identical bank excavation and placement of slope containment within SMU-3, SMU-5, SMU-8, and SMU-11 (Figures 3, 4, and 5). This portion of the shoreline is degraded, containing chemical concentrations above the SQS criteria, highly armored, and over steepened (approximately 1:1 horizontal to vertical [H:V]) slope) banks, derelict creosote-treated piles, remnant overhanging asphalt pads, and other types of debris. The shoreline also generally lacks riparian cover except along the top of bank. No shoreline reconfiguration is proposed in SMU-1, which is abutted by the adjacent sheet pile wall and concrete panel walls.

SMU-3, SMU-5, SMU-8, and SMU-11 have been identified as potential contaminant sources to nearshore sediments due to bank soil/sediment SQS exceedances and the general presence of debris in these areas. Bank excavation and subsequent placement of slope containment would prevent the elevated chemical concentrations from entering the aquatic environment. The habitat condition in SMU-3, SMU-5, SMU-8, and SMU-11 following completion of the reconfiguration will be substantially improved over existing conditions.

The proposed bank reconfiguration extends from the top of the existing bank from approximately +19 to +20 feet MLLW down to 0 to +2 feet MLLW elevation. The lower elevation range was used for planning purposes in the Final EE/CA and was selected based on tidal variations and the reach length of typical long reach excavators. The preferred method for these activities will be to attempt to conduct excavation and capping occurring at the lower elevations during low tides below the 0 feet to 2 feet MLLW elevation range, to facilitate doing this work in-the-dry from the landside.

Existing derelict overhanging asphalt structures and debris would be removed from the bank prior to excavation and placement of slope containment. Upon excavation to the target depths, inert debris identified along the new surface may be allowed to remain in place if it is determined that it would not affect the function of the overlying engineered cap. An estimated 90 tons of debris would be removed and disposed of off-site.

The shoreline excavation is proposed to occur over a total distance of 605 linear feet. For the purposes of the Final EE/CA, the design excavation depth is 4 feet (includes 1 foot excavation tolerance) shoreward of the existing ground surface from the toe of slope upwards, with the resulting slope reconfigured to a gentler, more stable 2H:1V slope (Figures 3 through 5). The excavation (identical across Alternatives 2, 3, and 4) would result in the removal of approximately 6,000 cubic yards of impacted soil/fill and sediment, debris, and other encountered material and would create a gentler slope with increased intertidal habitat.

Following excavation, slope containment materials will be placed along the full length and height of the reconfigured slope. Based on experience at similar sites, the containment was assumed to be composed of a target 30-inch "filter" layer (sandy gravel to gravelly sand), overlain by a target 12-inch "armor" layer (riprap or cobble), further overlain by a target 6-inch layer of material augmented with habitat substrate (anticipated to consist of washed, 2-inch minus gravel).

The filter layer will act as the chemical isolation layer, the armor layer will function to protect the filter layer from erosion, and the habitat layer will provide the appropriate substrate for benthic and salmonid habitat. Application of the slope containment would result in the placement of approximately 2,200 cubic yards of filter layer, 900 cubic yards of armor layer, and approximately 300 cubic yards of a habitat layer (for a total placement volume of approximately 3,400 cubic yards) over approximately 0.38 acre. The amount of armor material required will be minimized as much as possible during design to maximize habitat considerations while ensuring erosion protection.

The specific containment materials and configuration of the bank excavation will be determined during design. Clean (as defined in the Action Memorandum [EPA 2011]) containment material is expected to be imported by land from a borrow quarry to the RAB with dump trucks or by water on barges. The caps will be designed in general accordance with applicable EPA and U.S. Army Corps of Engineers (USACE) capping guidance and would include an evaluation of slope stability, propeller wash scour, isolation effectiveness for the identified chemical concentrations below the cap, erosion during design river discharge events, and seismic stability. For the purposes of the Final EE/CA, the maximum shoreline containment slopes (2H:1V) and materials identified were consistent with regional embankment designs that meet modeled and proven seismic stability. During design, appropriate seismic design criteria will be developed, and slopes or materials may be modified to ensure seismic stability.

3.5.2 *Sediment Capping and Backfill*

The purpose of sediment capping is to physically and chemically isolate surface sediments exhibiting concentrations of chemicals of concern above the total PCB RvAL to limit exposure to elevated chemical concentrations in surface sediments within the RAB. The only areas proposed for capping without first conducting dredging are in SMU-1A and SMU-1B in Alternative 2, as described in the following sections.

As described in the Final EE/CA, material that is placed as part of the selected remedy will either be designated as backfill or engineered cap material. This designation will be based on the pre-removal sediment total PCB concentrations that will either be at the bottom of the dredge cut or the sediment total PCB concentrations at the base of the engineered cap in areas where dredging is not conducted. Total PCB concentrations that are above the RvAL will be designated cap material and concentrations below the RvAL will be designated as backfill material. Both types of material placement have similar construction requirements, but the engineered cap includes armoring to provide physical isolation of elevated chemical concentrations. For alternatives including engineered capping, the specific cap configurations would be determined in the design in accordance with EPA (1998) and USACE guidance and would include at a minimum an evaluation of slope stability, wind wave analysis, propeller wash scour, isolation effectiveness for the identified chemical concentrations below the cap, erosion during design river discharge events, and seismic stability. As previously described, the isolation or engineered cap was assumed to be composed of a 30-inch filter layer (sandy gravel to gravelly sand), overlain by a 12-inch armor layer (riprap or cobble), further overlain by a 6-inch layer of habitat substrate (anticipated to consist of washed, 2-inch minus gravel). All materials used for capping and backfill are anticipated to be obtained from established upland borrow sources and should be free of large organic or other waste or debris. All capping and backfill materials will have concentrations of all SMS-managed chemicals below the SQS criteria.

For Alternative 2, an engineered cap is proposed based on the existing data set in SMU-1A, SMU-1B, SMU-2, SMU-4A, SMU-4C, and SMU-9. Backfill is proposed for SMU-4B, SMU-6, SMU-7, and SMU-10 given the proposed removal in these areas will remove the full vertical extents of the total PCB RvAL exceedances (Figure 3). For Alternative 3, caps would be the same as Alternative 2, with the exception that SMU-1A would be designated as backfill (Figure 4). Alternative 4 would only include the placement of backfill material given the full vertical extents of total PCB RvAL would be removed (Figure 5).

Following the placement of the capping material, a bathymetric survey of capped aquatic areas will be completed to verify and document that the cover meets the design specification with allowable overplacement. Upon completion of the selected remedy, the entire area of the RAB would be covered with a combination of capping, backfill, and clean material placement to a minimum depth of 45 centimeters, which is the EPA-directed vertical point of compliance for the removal action.

3.5.3 Sediment Dredging

Section 404(b)(1) regulates the discharge of dredged material or fill into waters of the United States. Prior to December 2008, as regulated by the USACE and EPA under Section 404 of the CWA (33 CFR §323 and 40 CFR §232, respectively) the definition of *discharge of dredged material* included "incidental fallback" of dredged material during dredging activities. Per Volume 73 Federal Register 79641 (issued December 30, 2008), incidental fallback from dredging activities is no longer considered a discharge of fill under the Section 404(b)(1), so long as it can be demonstrated that this material does not lead to the significant degradation of waters of the United States, either in an individual action or cumulatively. Therefore, although dredging is not technically an action regulated under Section 404(b)(1), it is included in the discussion of impacts in this document for purposes of establishing that a sufficient level of ecological function is maintained, replaced or restored in the watershed in order to demonstrate substantive compliance with CWA and ESA, which are applicable or relevant and appropriate requirements (ARARs) for the RAB.

The purpose of sediment dredging is to remove surface and subsurface sediments exhibiting elevated concentrations of chemicals of concern within the RAB and to dispose of them at an EPA-approved upland landfill. This removal would serve to eliminate:

1. Exposure to the highest risk surface sediments within the RAB
2. A significant mass of contaminated sediments at depth from within the RAB

Dredge design is based on surface and subsurface exceedances of the total PCB RvAL (12 mg/kg normalized for OC content). All other elevated concentrations of chemicals of concern within these SMUs would be remediated upon removal of total PCB concentrations above the RvAL. The dredging will target the removal of the full depth of total PCB RvAL exceedances within each the in-water SMUs based on the existing subsurface core data. Based on current information, the dredge cuts would vary in thickness between 1 foot and 10.5 feet and the contractor would be allowed an additional overdredge tolerance of 1 foot.

Post-dredge surveys will be performed to confirm contractor estimates of sediments removed from the target areas and to ensure that target depths are achieved. If the post-dredge survey shows that the target elevations were not achieved, the contractor will perform the necessary additional dredging. A final post-dredge survey will be performed to document the post-construction mudline elevations.

For Alternative 2, sediment dredging is proposed within SMU-2, SMU-4A, SMU-4B, SMU-4C, SMU-6, SMU-7, and SMU-9, and SMU-10 (Figure 3). For Alternative 3, sediment dredging is identical to Alternative 2 but also includes dredging in SMU-1A and SMU-1B (Figure 4). For Alternative 4, dredging is proposed within all the SMUs included in Alternative 3, but dredge elevations are deeper in some SMUs to facilitate complete removal of the vertical extents of total PCB RvAL exceedances (Figure 5).

Approximately 9,900 cubic yards would be expected to be removed for dredging for Alternative 2; 11,000 cubic yards of material would be expected to be removed for dredging for Alternative 3; and up to 22,000 cubic yards of material proposed would be removed for dredging in Alternative 4.

In each action alternative, dredging will be followed by the placement of clean material to bring the area back to existing grade in all areas except SMU-4B. The final elevations in the near channel portions of this SMU will not be brought back to grade due to requirements to accommodate potential future maintenance dredging by USACE within and directly adjacent to the federal navigation channel. The clean material is anticipated to increase the habitat quality of the post-construction surface through placement of habitat substrate (for example, 2-inch minus material) in the upper 6 inches.

The long-term monitoring requirements in each of the in-water SMUs will be based on the pre-removal sediment total PCB concentrations existing at the bottom of the designed dredge cut. Total PCB concentrations that are above the RvAL will be designated cap material and concentrations below the RvAL will be designated as backfill material. Areas designated as capped areas will include necessary long-term monitoring to assess the performance and integrity of the cap over time. Areas designated as backfill material will have no long-term monitoring requirements, unless required by EPA to provide an evaluation of surface sediment concentrations based on ongoing river-wide sources of chemical concentrations. If required, this monitoring data would not trigger any corrective actions if upland sources from the Facility are documented as controlled.

3.6 Construction Methods

All discharges of material will occur directly (for example, via placement of capping materials, backfill, or the habitat layer) and indirectly (for example, through possible erosion of material placed as part of bank reconfiguration).

The methods that will be used to implement the removal action will be more specifically developed during the design phase, but at this time are expected to include the following:

- Bank reconfiguration is expected to occur using land-based excavation equipment (for example, excavators, front-end loaders, and dump trucks). The removed material is expected to be stockpiled on the Facility in an area that adequately contains the material, and then transferred to trucks or rail cars for transport to the Subtitle D landfill. The slope containment is expected to occur using the same type of land-based excavation equipment. It is expected that the slope containment materials will be placed in-the-dry to the extent possible.

- Dredging is anticipated to be completed using mechanical methods. Specifically, as discussed in Appendix E of the Final EE/CA (Anchor QEA 2011a), dredging is expected to be performed using an excavator with an articulated, enclosed bucket, to the extent possible. Large debris piles that have been identified in the removal action area, such as trees, large concrete blocks, intact and broken pilings, and molten debris piles, are likely beyond the lifting capacity of this type of bucket. In areas where this type of bucket is unable to remove the encountered material, a heavier bucket with digging capabilities or a conventional wire-supported clamshell dredge, grapple, or vibratory hammer would be necessary. The removed materials are expected to be placed on a barge equipped to hold dredge material and water, and transported to a nearby EPA-approved offloading facility. At this location, the material on the barge would be offloaded and treated to reduce water in the sediment prior to placement onto trucks or railcars, or would be offloaded directly into trucks or railcars for transport to the landfill.
- Placement of cap/backfill material is expected to occur from the water side using mechanical methods with a clamshell bucket on a barge. The clamshell bucket would release capping material just above the water line in areas identified for capping. The work is expected to occur at higher tides as needed to provide the required depth to accommodate the equipment.

3.7 Timing of Discharge

Federal and state agencies have established work windows to be protective of potential effects to listed species due to construction activity. In the LDW, the Washington Department of Fish and Wildlife (WDFW) has recommended the following in-water work windows:

- **Salmon**: July 2 to March 2
- **Bull Trout:** October 1 to February 15
- **Surf Smelt:** April 1 to August 31
  - Does not apply because there is no surf smelt spawning habitat (that is, sand/gravel substrate in the intertidal and upper intertidal area) in the project area
- **Pacific Herring:** May 1 to January 14

- Does not apply due to there not being any herring spawning habitat (that is, eelgrass) in the project area

- **Sand Lance:** March 2 to October 14
  - Does not apply due to there not being any sand lance spawning habitat (that is, sand/gravel substrate in the intertidal and upper intertidal area in the project area)

For these reasons, the window that applies to this work is October 1 to February 15 to account for salmon and bull trout species that could be impacted by the proposed removal action. The removal action is expected to span approximately 4.5 weeks of in-water work and approximately 8 weeks to complete. The specific project timing details will be developed by the selected contractor as part of the removal action work plan documents.

Another timing consideration is the Muckleshoot Tribe's netfishing activities as the proposed action will occur within a netfishing area. As stated in the LDW Draft Final Feasibility Study (FS; AECOM 2010), the Muckleshoot Tribe's netfishing activities within the LDW over the last few years have sometimes extended through October and well into November, which extends into the in-water work period. EMJ and Jorgensen Forge in coordination with EPA will work closely with the Muckleshoot Tribe prior to and during implementation of the proposed action to limit the conflicts between remediation and netfishing activities.

To reduce potential impacts associated with neighboring cleanup activities, the MOU requires that the adjacent Boeing DSOA corrective action and EMJ and Jorgensen Forge removal action occur concurrently, to the extent feasible. The Boeing DSOA corrective action is currently in the design phase with a target construction date of 2012. Delays in planning and design phases of these concurrent projects may result in delays to initiation of the removal action at the Facility.

3.8 Sources and General Characteristics of Capping, Backfill, and Habitat Layer Materials

The sources of capping, backfill, and habitat layer materials will be identified based on criteria identified during the design process. The EPA Action Memorandum (2011) requires that sediment containment materials will be comprised of imparted material that contains chemical concentrations at or below natural background chemical concentrations. Further, these materials will be obtained from established upland borrow sources, free of large organic or other waste or debris, and have chemical concentrations below the SQS criteria and anticipated target media cleanup levels to be established in the Record of Decision (ROD).

3.9 Quantity of Material to be Removed and Discharged

The expected quantity of material to be removed and discharged as part of the removal action alternatives is provided in Table 2. As previously noted, removal of material would occur for bank excavation and dredging to remove sediments with chemical concentrations above the total PCB RvAL exceedances.

Table 2
Expected Quantity of Material to be Removed and Discharged as Part of the Removal Action Alternatives

Quantity	Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4
Total Quantity Removed (cubic yards)	None	• 6,000 (bank slope) • 9,900 (dredging) • 15,900 Total	• 6,000 (bank slope) • 11,000 (dredging) • 16,800 Total	• 6,000 (bank slope) • 15,000 to 20,000 (dredging) • Up to 26,000 Total
Total Quantity Discharged (cubic yards)[1]	None	• 3,400 (bank cap) • 8,900 (cap/backfill) • 12,300 (total)	• 3,400 (bank cap) • 8,800 (cap/backfill) • 12,200 (total)	• 3,400 (bank cap) • 15,000 – 18,000 Backfill • Up to 24,000 total

Notes:
1 Discharge includes materials placed for capping, backfill, and slope reconfiguration.

4 RESOURCE IMPACT EVALUATION CRITERIA

Section 404(b)(1) guidelines require evaluation of the aquatic impacts associated with the discharge of dredged or fill material. The purpose of Section 404(b)(1), as per 40 CFR § 230.10(a) "is to restore and maintain the chemical, physical, and biological integrity of waters of the United States through the control of discharges of dredged or fill material." Specifically, 40 CFR § 230.10(c) states that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact."

Section 230.11 of Subpart B of the Guidelines provides the four conditions that must be satisfied in order to make a finding that a proposed discharge complies with the requirements described in 40 CFR § 230. These four conditions include:

1. No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental impacts (see Section 2.3)
2. No discharge of dredged or fill material shall be permitted if it violates any water quality standards, jeopardizes any endangered or threatened species, or disturbs any marine sanctuaries (see Sections 4 and 5)
3. No discharge of dredged or fill material shall be permitted that will result in significant degradation of any waters of the United States, including adverse effects on human health or welfare, effects on municipal water supplies, aquatic organisms, wildlife, or special aquatic sites (see Sections 6 and 7)
4. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that will minimize potential adverse impacts (see Sections 8, 9, and 10)

The potential impacts of the proposed removal action are evaluated based on conditions set forth in 40 CFR Subpart B § 230.11, and the factual determination and discussion of conditions for compliance are provided in Sections 11 and 12.

5 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

5.1 Substrate

5.1.1 Existing Conditions

The sediments within the RAB have been characterized during a number of investigations, most recently by Boeing (MCS 2004), EMJ and Jorgensen Forge (Anchor and Farallon 2008), a joint effort by USACE and EPA (Herrera and USACE 2008), EPA (Windward 2007a, 2007b), and Anchor QEA, LLC (2011, to be reported in forthcoming design deliverables). The dominant substrate size is angular rock near the shore, grading to mud and silt in the intertidal zone. As the shoreline levels out from the bank, a mudflat is exposed at low tide (see Section 7.3). Surface sediment percent fines adjacent to the shore were tested and found to contain less than 20 percent along the shoreline above the 0 feet MLLW elevation, ranged between 60 and 80 percent along the northwestern corner of shoreline, and ranged between 20 and 60 percent along the middle/southern portion of the shore. In general, the fines content increases with distance from the shoreline bank, indicating a lack of accretion along the mid-upper shoreline bank (Anchor and Farallon 2008).

5.1.2 Impacts

5.1.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing substrate conditions.

5.1.2.2 Action Alternatives 2, 3, 4

The bank stabilization, dredging, and discharge of slope containment material as proposed in three of the alternatives for the RAB will alter the substrate characteristics of the Facility.

In areas where bank reconfiguration is proposed, the physical characteristics of the bank will be modified and new, clean substrate will be introduced, stabilizing the bank and preventing further erosion of contaminated material into the river.

The caps proposed to be placed in the RAB under Alternatives 2 and 3 will isolate the underlying chemically contaminated substrate and bring elevations back up to grade after dredging (with the exception of SMU-4B in the federal navigation channel, which will not be brought up to grade due to potential USACE future maintenance dredging requirements). Habitat material will be placed over the armor layer. This will result in improved habitat that is similar in topography and substrate characteristics. Overall, the removal actions proposed under all the alternatives will provide improved habitat conditions for benthic organisms and aquatic species.

Dredging will alter bottom topography and disturb the existing benthic community, but removal of the highest chemical concentrations and replacement with clean substrate brought back to the original grade will provide a new surface available for colonization by new benthic organisms and invertebrates.

5.1.3 Summary

All of the removal action alternatives described in Section 3 would result in long-term benefits to substrate in the RAB through removal of chemical contamination. Further, all alternatives would result in the entire RAB being covered by a minimum of 45 centimeters of clean material. Compared to Alternatives 2 and 3, Alternative 4 will result in the complete removal of impacted material, resulting in a lower risk than with contaminants capped in place.

5.2 Suspended Particulates/Turbidity

5.2.1 Existing Conditions

Information is not readily available on turbidity under historic conditions in the Duwamish River or RAB. The hydrology of the lower Duwamish River has been substantially altered from historical conditions through diversion of other tributaries in the watershed; this has reduced the Duwamish/Green River system by about 2/3 of its original watershed (NOAA 2005). The loss of floodplain connectivity has likely altered sediment inputs to the system as well as turbidity conditions. The Duwamish River receives water from runoff and outfalls throughout the Green River watershed, including stormwater, industrial and municipal stormwater outfalls, and runoff from a highly developed basin dominated by high-intensity land use. There are no long-term water quality monitoring stations on the Duwamish River; however, there is one station on the lower Green River in Tukwila, approximately 7 miles upstream of the LDW (King County 2010). The water quality at this station exceeds standards for suspended solids and turbidity (King County 2010).

5.2.2 Impacts

5.2.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing turbidity/suspended substrate conditions.

5.2.2.2 Action Alternatives 2, 3, 4

Some localized increases of suspended particulate levels and turbidity above ambient river conditions are expected during dredging of sediments and discharge of fill material. These effects are considered minor but unavoidable. BMPs described in Section 10 and in the Final EE/CA Appendix E will be employed during bank reconfiguration, dredging, and backfill/capping activities to minimize the potential for increased suspended sediment and turbidity levels. For example, due to the potential for vessel traffic in the dredging and capping areas, operational controls (as opposed to a silt curtain or similar device) are considered the most effective measure for control of turbidity. An example of an operational control is to minimize sediment suspension by progressively slowing construction activities until turbidity exceedances are no longer detected outside of the compliance boundary, or by shortening dredging cycle times to decrease turbidity plumes until the suspended sediment settles.

In addition, all dredging operations will be monitored closely and managed carefully to minimize suspended sediment effects according to the CWA Section 401 Water Quality Certification (WQC) for the project. Turbidity levels will be monitored at the compliance boundary (mixing zone is expected to extend 300 feet radially from the work area) during bank reconfiguration, dredging, and capping, and activities will be suspended if turbidity levels increase above regulated levels.

5.2.3 Summary

Turbidity arising from discharge of fill material is expected to dissipate quickly. Due to the short-term nature of the disturbance and clean state of materials being used for capping or backfill, suspended particulates resulting from this activity are not expected to have a permanent or negative impact on the aquatic ecosystem. Dredging related turbidity is not anticipated to have a substantial adverse effect on the aquatic environment due to the short-term and localized nature of the potential impact. In addition, impact avoidance and minimization measures would be implemented to minimize the potential for turbidity increases. All of the potential cleanup activities described result in long-term benefits to aquatic resources from the sediment quality improvements. Compared to Alternatives 2 and 3, Alternative 4 will result in the complete removal of contaminants, resulting in a lower risk than with contaminants capped in place.

5.3 Water Quality

5.3.1 Existing Conditions

The most recent Washington State Water Quality Assessment identifies locations throughout the LDW and Duwamish River that are impaired based on CWA 303(d) and 305(b) criteria (Ecology 2009). The waters in the vicinity of the RAB are listed as Category 5 waters for dissolved oxygen and fecal coliform. Downstream of the RAB, the LDW is also listed for these parameters. The water in the project area is not currently listed on Ecology's Water Quality 303(d) list (303(d) list) for any chemical contaminants or nutrients (Ecology 2009). Water quality in the LDW is significantly influenced by activities occurring throughout the watershed.

Temperatures in the mainstem Duwamish River are high because measured temperatures in the Green River during the summer have peaked between 23 and 24 degrees Celsius (°C) at stations in the lower and middle Green River. Ecology's Aquatic Use Category sets criteria for the protection of spawning, rearing, and migration of salmon and trout, and other associated aquatic life. Several different aquatic use categories have been assigned to various reaches of the Duwamish/Green River (Water Resource Inventory Area [WRIA] 9). The reach of the Duwamish River from the mouth of the river at Elliott Bay to RM 11.0 is categorized for aquatic life use as a "Salmon/Trout Rearing/Migration Only" area. The limiting factors analysis for WRIA 9 states that in some years, this is probably of concern for adult Chinook migration up the Green River (King County 2005). The analysis also stated that turbidity and total suspended solids (TSS) are possible factors of decline in terms of water column impacts for the Duwamish River, but that no information on duration was available. A previous limiting factors analysis stated that risks to water column dwelling organisms are minimal (King County 2000).

5.3.2 Impacts

5.3.2.1 No Action Alternative

Under the No Action Alternative, existing water quality conditions would continue to be degraded by presence of contaminated sediments in the RAB.

5.3.2.2 Action Alternatives 2, 3, 4

The primary goal of the proposed action is to reduce the potential exposure of aquatic organisms to chemical contaminants in the sediments. Certain parameters for which the LDW is on the 303(d) list, such as dissolved oxygen (DO) and fecal coliform are influenced by practices in adjacent and upriver communities and will not be specifically addressed through the removal action in the RAB. As part of the removal action, physical disruption of the contaminated sediments during the implementation of Alternatives 2, 3, and 4 is necessary and a minor amount of turbidity increase is expected to occur.

The dredging actions in Alternative 3 and 4, mainly in subtidal areas and potentially in intertidal and bank areas (if not dredged in-the-dry), could potentially cause a short-term increase in concentration of some chemicals in the water column in the immediate vicinity of the dredging because of resuspension of sediment or desorption of the contaminants from the sediment particles. If present in the water near the dredge action, aquatic species could experience increased exposure to contaminants, and if this condition persists over a long period, exposure could present a risk of increased bioaccumulative chemicals in tissue. However, suspended sediment increases that may occur during dredging are expected to be short-term and localized.

Based on the results of sediment sampling within the RAB, the potential acute exposure of contaminants during dredging in the Action Area could include PCBs, metals, and polycyclic aromatic hydrocarbons (PAHs). Acute thresholds are used for dredging because dredging activities are generally intermittent throughout a day and do not occur continuously. Potential effects to listed salmonids and bull trout from exposure to these three chemical groups are described in the BA for this project (Anchor QEA 2011b). In summary, the general impact to water quality from each of these contaminants is as follows:

- **PCBs:** Due to their low water solubilities, PCBs predominantly partition with the sediment and suspended particulate phases in aquatic environments. Dredging may temporarily disturb sediments, resuspending PCB contaminated particulate and releasing porewater with PCBs into surface water. While some of the disturbed sediments may release potentially bioavailable PCBs, observations made during other field studies have indicated that PCB releases were small in comparison to the effective dilution of the receiving system (Anchor Environmental 2003). The studies found that the concentration of PCBs in the water column tended to be minimal and were often below detection limits (Anchor Environmental 2003).
- **Metals:** Desorption of metals from suspended sediments are a potential concern during dredging. Different studies have shown that metal concentrations in interstitial (pore) water are correlated with observed biological effects (Ankley et al, 1996, as cited in Anchor Environmental 2003). However, based on laboratory results and field observations (Brannon et al. 1976, Lee et al. 1975, Wright 1978, Hirst and Aston 1983; all as cited in Anchor Environmental 2003), EVS Environment Consultants (1997, as cited in Anchor Environmental 2003) many studies have concluded that during dredging, releases of dissolved metals from the sediments, even in highly contaminated areas, were minimal. Even though release of total metals can be large, concentrations of dissolved metals are, in general, low and of short duration (CEM 1983, as cited in Anchor Environmental 2003). In addition, a key BMP that will be implemented during dredging is that intertidal and shoreline bank areas will be dredged in-the-dry to the extent practicable to minimize the potential for contaminant resuspension. All of the metals exceedances occur in intertidal areas.
- **PAHs:** Studies of organic contaminant releases to the water column during dredging have been conducted in the past (Ludwig and Sherrard 1988, Brannon 1978, Thomann and Connolly 1984, Thomann 1989, Hydroqual 1994; all as cited in Anchor

Environmental 2003). Theoretically, the equilibrium exchange can allow for release during the dredging of impacted sediments, and the concentrations of soluble, available organic compounds in water could therefore increase above ambient levels. However, observations made during field studies, indicated that the releases were small in comparison to the effective dilution of the receiving system, and any changes in the water quality were transient, even when grossly contaminated sediments were dredged (Ludwing and Sherrard 1988, Brannon 1978; both as cited in Anchor Environmental 2003).

Similar results have been observed for PAHs measured during dredging projects. Monitoring conducted at the ports of Los Angeles (Berths 167-169, 148-151, 261-265, and 212-215) and Long Beach (Pier T) show PAH concentrations in the water column that are a fraction of that observed in the sediments (MBC 2001a, 2001b, 2001c, 2001d, 2001e, and 2001f; all as cited in Anchor Environmental 2003). For example, dredge monitoring at Port of Los Angeles Berths 261-265 showed PAH concentrations that were 4 to 6 orders of magnitude lower than the concentrations measured in the sediments. In sediment core samples, total PAH concentrations ranged from 9 to 52 parts per million (ppm), while water column concentrations ranged from 0.098 to 1.5 parts per billion (ppb) (MBC 2001e, as cited in Anchor Environmental 2003). In addition, a key BMP that will be implemented during dredging is that intertidal and shoreline bank areas will be dredged in-the-dry to the extent practicable to minimize the potential for contaminant resuspension. All of the PAH/SVOC exceedances occur in intertidal areas.

The duration for the potential for exposure related to dredging is approximately 4.5 weeks of the in-water work window during construction. The potential for exposure to occur related to dredging is not constant, but rather intermittent as the dredging activity is not expected to occur constantly over the 4.5 week period. Moreover, the in-water work window is set for the time when very few juvenile salmon and bull trout are expected to be in the vicinity. Furthermore, the length of time that sediments are resuspended plays a critical role in determining the chemical impacts to the water column (Tomson et al. 2003, as cited in Anchor Environmental 2003) for dissolved phases. It has been shown that the vast majority of resuspended sediment settles close to the dredge within 1 hour and only a small fraction takes longer to resettle (Wright 1978, Van Oostrum and Vroege 1994, Grimwood 1983; all as cited in Anchor Environmental 2003). Therefore, it is expected that for this proposed action, a majority of the resuspended sediments would settle in the vicinity of the dredging activity, and that an inconsequential amount would travel downstream to other areas of the LDW.

Overall, the information provided suggests that potential water quality impacts related to resuspended sediment contaminants are low. In addition, following dredging, the concentration of the surface left after dredging and backfilling with imported material will be lower than the existing surface.

Short-term effects to water quality related to other conventional parameters such as DO, turbidity, and pH may occur due to re-suspended sediment. However, these impacts are similarly expected to be limited, short term, and localized and not expected to result in any long-term effects.

5.3.3 Summary

In the long term, water quality conditions are expected to improve because of removal or isolation of existing contaminated sediments in the RAB under all removal action alternatives. Water quality within the RAB will be monitored in accordance with the appropriate regulations. Long-term negative water quality impacts are not expected because of any actions proposed under the alternatives. All of the potential cleanup alternatives described result in long-term benefits to aquatic resources. While short-term water quality impacts are more likely to occur during dredging actions rather than via placement of clean cap materials and backfill, none of the alternatives are likely to generate long-term water quality impacts. Despite the greater likelihood of water quality impacts related to resuspension of sediments during dredging, compared to Alternatives 2 and 3, Alternative 4 will result in a lower risk associated with complete removal of impacted material than with contaminants capped in place.

5.4 Current Patterns, Water Circulation and Fluctuations

5.4.1 Existing Conditions

The current hydrogeology of the LDW is a result of both geologic events in pre-Columbian history (e.g., volcanic lahar flows) and anthropogenic events that have occurred since the early twentieth century (e.g., channel straightening, dredging, and filling; AECOM 2010). Floodplain connectivity is limited in the RAB and throughout the LDW due to industrial activities and urbanization. The lack of connectivity as well as presence of upstream dams permanently altered the natural hydrograph of the river.

Water circulation and hydrology within the LDW estuary are affected by tidal action, river flow, and the salt wedge where the freshwater from the Duwamish/Green River system meets and overlies the denser saltwater from Elliott Bay. Limited mixing occurs where the two meet (AECOM 2010).

5.4.2 Impacts

5.4.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing current patterns, water circulation, or fluctuations.

5.4.2.2 Action Alternatives 2, 3, 4

The implementation of removal actions in the RAB would not have a significant impact on local or river-wide current patterns, water circulation, or water fluctuations. Alternatives 2, 3, and 4 would result in no significant change to elevations; placement of backfill will bring dredge areas back to existing grade or slightly lower elevations to accommodate future maintenance dredging actions in the RAB.

5.4.2.3 Summary

None of the proposed alternatives would have an impact on current patterns, water circulation, or fluctuations.

5.5 Salinity

5.5.1 Existing Conditions

The LDW is an estuarine system. The salinity of the surface water varies with river flow and tidal conditions; during times of high river flow, the salinity in the surface water is low, whereas during low-flow conditions, the surface water salinity is higher (AECOM 2010). The thickness of the freshwater layer increases throughout the LDW as the river flow rate from the Duwamish/Green River system increases. When freshwater input from the Duwamish/Green River system is greater than 1,000 cubic feet per second (cfs), the saltwater wedge does not extend upstream beyond the East Marginal Way South Bridge (RM 6.3; upstream of the RAB), regardless of the level of the tide. During high-tide stages and periods of low freshwater inflow, the saltwater wedge has been documented as extending as far upstream as the Foster Bridge (RM 8.7; Stoner 1967, as cited in AECOM 2010). At the river's mouth at the northern end of Harbor Island, a salinity of 25 parts per thousand (ppt) is typical for the entire water column; salinity decreases toward the upriver portion of the estuary.

5.5.2 Impacts

No change is expected in the overall salinity gradient of the river under the No Action Alternative, nor as a result of implementation of any of the proposed alternatives.

6 POTENTIAL IMPACTS ON BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM

6.1 Threatened and Endangered Species

EMJ and Jorgensen Forge have prepared a BA for the proposed removal action (Anchor QEA 2011b). The BA will be used by EPA for consultations with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to ensure compliance of the preferred alternative with the ESA.

6.1.1 Existing Conditions

Species with federal ESA status that may occur in the RAB include Chinook salmon (*Oncorhynchus tshawytcha*) Puget Sound Evolutionary Significant Unit (ESU), steelhead (*Oncorhynchus mykiss*) Puget Sound Distinct Population Segment (DPS), and bull trout (*Salvelinus confluentus*) Coastal Puget Sound DPS.

6.1.2 Impacts

6.1.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions, and threatened and endangered species would continue to be exposed to contaminants in the sediments of the RAB.

6.1.2.2 Action Alternatives 2, 3, 4

Potential direct and indirect impacts of the preferred alternative on Pacific salmonids and bull trout assessed in the BA include those resulting from disturbance to food sources, entrainment in dredge equipment, water quality impacts, and alteration of nearshore habitat (Anchor QEA 2011b). Although some individual organisms may experience short-term adverse effects, the proposed removal action will provide long-term benefits for listed species by removing contamination from the RAB. In addition, as a result of the shoreline reconfiguration proposed under all the active alternatives, the removal action will result in a slight increase of shallow water habitat (that is, habitat shallower than -10 feet MLLW), which is important for juvenile salmonid migration and rearing (see Section 5.1.2.2 of the EMJ and Jorgensen Forge BA [Anchor QEA 2011b]).

6.1.3 Summary

Although there is a potential for individual fish to experience injury or mortality as a result of the implementation of the proposed alternatives, the overall impact of the completed project on listed species is anticipated to be a net long-term benefit. All of the potential cleanup activities result in long-term benefits to threatened and endangered species due to the removal of contaminated sediments and placement of clean substrate. Compared to Alternatives 2 and 3, Alternative 4 will result in the complete removal of contaminants, resulting in a lower risk than with contaminants capped in place.

6.2 Aquatic Food Web

6.2.1 Existing Conditions

According to information in the Remedial Investigation and Feasibility Study (RI/FS), the benthic invertebrate community within the LDW is dominated by annelid worms, mollusks, and crustaceans (AECOM 2010, Windward 2010). Crustaceans are the most diverse of these three groups in the LDW, with the most abundant large epibenthic invertebrates including slender crabs, crangon shrimp, and coonstripe shrimp (AECOM 2010). Dungeness crabs are also common, although their distribution is typically highest in the areas closer to Elliott Bay (AECOM 2010). Mollusks include various bivalves and snails. Although the vast majority of benthic invertebrate species in the LDW are typical inhabitants of estuarine environments, a few organisms more typical of freshwater environments, such as chironomids, were found below RM 2 (Windward 2010).

Baseline chemical characteristics of sediments in the RAB indicate that concentrations of several inorganic and organic compounds present in sediments may affect benthic invertebrates, fish, and wildlife. Under current conditions, the food chain may be adversely impacted due to the presence of these chemicals.

6.2.2 Impacts

6.2.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions, and aquatic organisms in the food web would continue to be exposed to contaminants in the RAB sediments. This would lead to ongoing source for bioaccumulation in the food web.

6.2.2.2 Action Alternatives 2, 3, 4

Bank reconfiguration, dredging, and containment activities will either remove or isolate the elevated sediment chemical concentrations from exposure to aquatic receptors, precluding the availability of the contaminated sediment throughout the food chain. In particular, the removal action will remove sediment containing PCBs, which are a bioaccumulative and move through the food chain. Dredging and discharge of fill materials for capping or backfilling may disrupt existing benthic invertebrate communities and fish access to the RAB during implementation of the project, but this is anticipated to be a minor loss to the aquatic food web. Under all proposed alternatives, access to the RAB for fish will be unobstructed upon completion of the removal action and recovery of the benthic community is expected to begin shortly after impact (i.e., within 1 year).

6.2.3 Summary

It is anticipated that implementation of the proposed alternatives would lead to reductions in contaminant exposure, especially PCBs, that will provide a significant overall improvement over existing conditions for aquatic organisms and the aquatic food web. It is anticipated that Alternative 4 would have less impact on mudflats due to the fact that no capping armor material would be necessary, and, therefore, minimize conversion of habitat. Compared to Alternatives 2 and 3, Alternative 4 will result in the complete removal of material above cleanup criteria, resulting in a lower risk to the benthic community and aquatic food web than with chemical contaminants capped in place.

6.3 Wildlife

6.3.1 *Existing Conditions*

The aquatic and semi-aquatic habitats of the LDW support a diversity of wildlife species. Formal studies, field observations, and anecdotal reports indicate that up to 87 species of birds and 6 species of mammals use the LDW at least part of the year to feed, rest, or reproduce (Windward 2010). Information about how these species use LDW habitats can be found in the RI (Windward 2010 Appendix A).

Diversity and abundance of birds was noted in previous studies to be highest closer to Elliott Bay (Canning et al, as cited in Windward 2010). Surveys conducted as part of the RI sandpiper habitat study noted more than 20 species of birds in the LDW area, for example, more than 10 passerine/upland bird species; raptors such as bald eagle and osprey; shorebirds such as the great blue heron; seabirds such as gulls and double-crested cormorants; and waterfowl such as Canada geese, ducks, and common mergansers (Windward 2010).

As an active industrial area, present use of the RAB by terrestrial mammals is limited. Mammals such as raccoons, muskrats, and river otters may be found in the uplands, and three marine mammal species are known to enter the LDW (harbor seal, California sea lion, and harbor porpoise; Windward 2010). Humpback whales, killer whales, and sea turtles are extremely unlikely to be in this part of the estuary.

6.3.2 *Impacts*

6.3.2.1 *No Action Alternative*

Under the No Action Alternative, there would be no change to existing conditions, and wildlife would continue to be exposed to contaminants in the RAB through ingestion of other aquatic organisms.

6.3.2.2 *Action Alternatives 2, 3, 4*

Bird and wildlife use and access may be disrupted during construction and presence of equipment and workers involved in the action. Each removal action alternative will have the same impact along the shoreline due to the identical shoreline reconfiguration activities proposed. Each removal action alternative will involve some in-water work, and the equipment used for dredging and capping activities is substantially the same, resulting in little difference in the amount of noise generated in any alternative that could impact wildlife. The dredging action may result in temporary impacts to water quality, but this is not likely to have an effect on wildlife in the RAB or downstream due to the short-term nature of the impact. For each removal action alternative, the potential impacts to wildlife are anticipated to be short-term, confined to the approved in-water work window timing, and localized to the RAB.

6.3.3 Summary

Overall, the proposed removal action alternatives will improve the aquatic environment in the long term, which will improve habitat conditions for birds and wildlife that rely on the aquatic habitat in the RAB. Compared to Alternatives 2 and 3, Alternative 4 will result in the complete removal of contaminants, resulting in a lower risk to birds and wildlife than with chemical contaminants capped in place.

7 POTENTIAL IMPACTS ON SPECIAL AQUATIC SITES

7.1 Sanctuaries and Refuges

Not applicable to the RAB.

7.2 Wetlands

Not applicable to the RAB.

7.3 Mudflats

7.3.1 Existing Conditions

A mudflat is exposed at low tide in the vicinity of SMU-1A and SMU-1B; however, this mudflat contains impacted sediments which are proposed for remediation.

7.3.2 Impacts

7.3.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions and the mudflat would contain impacted sediments.

7.3.2.2 Action Alternatives 2, 3, 4

Under Alternative 2, the mudflat would be capped, and under Alternatives 3 and 4, SMU-1A and SMU-1B would be dredged and then backfilled or capped back to the existing grade. The cap and backfill under all alternatives will result in a temporary change in habitat type of the mudflat area, because the habitat layer and sandy material proposed for backfill are comprised of larger sized materials and low organic content. However, it is anticipated that the dynamics of the river will return the area to characteristic mudflat over a relatively brief amount of time.

7.3.3 Summary

Because of the removal action, reductions in contaminants exposure in the mudflat will provide a significant overall improvement over existing conditions for aquatic organisms and the aquatic food web organisms that rely upon the mudflat for habitat. Compared to

Alternatives 2 and 3, Alternative 4 will result in the complete removal of contaminants, resulting in a lower risk than with sediments capped in place.

7.4 Vegetated Shallows

There are no vegetated shallows in the RAB.

7.5 Riffle and Pool Complexes

There are no riffle and pool complexes in the RAB.

8 POTENTIAL EFFECTS ON HUMAN USE CHARACTERISTICS

8.1 Municipal and Private Water Supplies

8.1.1 Existing Conditions

Presently, there are no water intakes at or in the vicinity of the RAB. The *2001 Central Puget Sound Regional Water Supply Outlook* (CPWSF 2001), an extensive assessment of water supply and demand in the three-county area including King, Pierce, and Snohomish Counties, does not indicate that the LDW is being considered as a source for King County municipal water supplies.

8.1.2 Impacts

8.1.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions.

8.1.2.2 Action Alternatives 2, 3, 4

No impact on municipal and private water supplies is anticipated due to any of the proposed alternatives.

8.1.3 Summary

No impact on municipal and private water supplies is anticipated due to the proposed alternatives.

8.2 Recreational and Commercial Fisheries

8.2.1 Existing Conditions

There is an active commercial Tribal fishery run by the Muckleshoot Tribe on the LDW, and some recreational fishing may occur in the LDW (Windward 2010).

8.2.2 Impacts

8.2.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions. Fish would continue to be exposed to impacted sediments in the RAB, leading to continued exposure through human consumption of fish species.

8.2.2.2 Action Alternatives 2, 3, 4

The dredging and/or capping activities conducted under each of the proposed alternatives will have some temporary effects on fish and fishing. As stated in the FS (AECOM 2010), the Muckleshoot Tribe's netfishing activities within the LDW over the last few years have sometimes extended through October and well into November, which extends into the in-water work period. EMJ and Jorgensen Forge, in coordination with EPA, will work closely with the Muckleshoot Tribe prior to and during implementation of the proposed removal action to limit the conflicts between remediation and netfishing activities.

In reaction to construction activities, fright response may lead to fish being temporarily driven from the area. Fish remaining in the area could be exposed to increased turbidity levels and resuspended sediment during dredging and cap or backfill placement. All recreational or commercial fishing activities would be displaced from the RAB vicinity during the project; however, construction would take place during the recommended work window (October 1 to February 15) when the fewest number of salmon species are expected to be in the area.

8.2.3 Summary

No long-term loss of fishing opportunities is expected because of dredging and capping activities, and elimination of contaminant exposure will contribute to a healthier fishery for the area, as well as reduce any possible human health risk associated with eating fish caught within the LDW. Placement of the habitat layer as part of capping in Alternative 2 and 3 would provide suitable habitat for fish species targeted by recreational fishers. Alternative 4 would result in the complete removal of impacted sediments, which would contribute to an immediate reduction of contaminants in the sediment. Additionally, the backfill material would also provide suitable habitat for fish species.

8.3 Water-related Recreation

8.3.1 Existing Conditions

Access to the shoreline bank area within the RAB is prohibited by an existing fence along the top of bank area. While there are residential areas bordering the LDW and public access points exist, it is not a major area for recreational use compared to other waterbodies in and around Seattle (Windward 2010). Potential recreational activities within and near the RAB that have been identified in other areas of the LDW include motor boating, kayaking, canoeing, and sport fishing. Due to the extensive commercial and industrial use of the LDW, recreational activities such as swimming, SCUBA diving, and windsurfing are not common (King County 1999).

8.3.2 Impacts

8.3.2.1 No Action Alternative

Under the No Action Alternative, there would be no change to existing conditions.

8.3.2.2 Action Alternatives 2, 3, 4

Any water-related recreation may be temporarily impeded by dredging, capping, and backfilling activities within the RAB, but this is expected to be a short-term impact, effective only while the in-water work is being conducted. Implementation of remediation may lead to improved recreational use due to improved public perceptions of the LDW. It is possible that where caps are proposed under Alternatives 2 and 3, institutional controls may be necessary to protect the cap from propwash, direct hull contact, and anchoring. The removal action proposed under Alternative 4 would not require such institutional controls as all impacted sediments would be removed and replaced with clean backfill.

8.3.3 Summary

All of the proposed action alternatives would temporarily impede recreational activity in the RAB during construction. However, this would be a short-term impact. Long-term impacts would be positive due to removal of contaminants from the sediments. Alternatives 2 and 3 could potentially require institutional controls to protect the capped areas, which could create restricted navigation areas, no wake zones, or no anchoring areas in the RAB. Alternative 4 would be unlikely to require these restrictions due to complete removal of impacted sediments.

8.4 Aesthetics

8.4.1 Existing Conditions

The RAB is located within a heavily industrialized area of the LDW in the City of Seattle. The industrial lands adjacent to the LDW serve as the Port of Seattle's primary marine shipping area, with deep water berths, wharfs, piers, shipyards, dry-docks, container cranes, on-dock rail, container yards, cargo distribution and warehousing, oil and petroleum storage facilities, and major railroad yards. The South Park neighborhood is across the LDW and supports additional industrial uses as well as residential, recreational, and commercial uses.

8.4.2 Impacts

8.4.2.1 No Action Alternative

Under the No Action Alternative, there would be no remediation, and therefore no change in existing aesthetic conditions.

8.4.2.2 Action Alternatives 2, 3, 4

Aesthetic impacts from implementation of the removal alternatives are unlikely. Construction will typically occur between 7:00 a.m. and 6:00 p.m. but may extend until no later than 9:00 p.m. based on City of Tukwila noise regulation (City of Tukwila Ordinance 1120). Transportation of the dredged material to Subtitle D landfill sites may also result in aesthetic impacts. Transportation and safety plans addressing hours of operations, estimated numbers of trucks and barges required for soil and sediment hauling, as well as anticipated transport routes and material spill prevention, containment, and response plans will be prepared by the selected contractor as part of the removal action work plan documents.

Aesthetic impacts of construction of Alternatives 2, 3, and 4 are generally negligible because the machinery and equipment used to construct each alternative would be aesthetically similar to the types of vessels and equipment typically found in an industrial harbor area (e.g., tugs, barges, and cranes). Public perception of the LDW aesthetics may improve as a result of implementation of a clean-up action.

8.4.3 Summary

No long term impacts to aesthetics are anticipated under any of the proposed alternatives, and short-term impacts are anticipated to be similar.

8.5 Navigation

8.5.1 Existing Conditions

The LDW supports commercial and recreational navigation. The LDW is maintained as a federal navigation channel by the USACE. Dredging for purposes of supporting navigation has occurred since approximately 1903 (Weston 1993, as cited in Windward 2010). The authorized depth ranges from -30 feet MLLW from Harbor Island to the 1st Avenue S Bridge to -15 feet MLLW at the Upper Turning Basin, which is the elevation maintained adjacent to the RAB (Anchor QEA 2011a; Windward 2010). The shoreline along the LDW contains features including piers, wharves, bulkheads, and buildings extending over the shore (Windward 2010). These structures are integral features of the active water-dependent industrial waterway.

Navigation that occurs within and adjacent to the RAB is limited and is associated with commercial vessel activities within the federal navigation channel. Due to depth limitations within the RAB, commercial vessels primarily maintain course within the channel. No Washington State Department of Natural Resources (WDNR)-permitted aquatic land uses exist within EAA-4 or at the upstream Boeing DSOA. Recreational navigation related primarily to recreational fishing does occur in the LDW and could occur near the RAB.

8.5.2 Impacts

8.5.2.1 No Action Alternative

In the No Action Alternative, sediments would not be removed and future maintenance dredging in the federal navigation channel may be constrained due to presence of impacted sediments.

8.5.2.2 *Action Alternatives 2, 3, 4*

Under the proposed alternatives, the surface elevations in the federal navigation channel were developed to accommodate requirements of future navigational maintenance dredging actions conducted by the USACE. In Alternatives 2 and 3, there would be engineered caps which would require long-term monitoring and maintenance to prevent erosion of the cap due to prop wash and wave action generated by vessel traffic as well as winds. Engineered cap areas would also require institutional controls, such as restrictions on navigation (e.g., potentially including slow and no-wake zones, no anchoring zones, or no grounding areas) to prevent the disturbance of the cap by both commercial and recreational vessels.

Under Alternatives 2, 3, and 4, use of small areas within the federal navigation channel may be disrupted due to presence of vessels during construction actions; however, it is expected that navigation within the federal navigation channel will not be substantially impeded.

8.5.3 *Summary*

No long-term impacts to navigation are anticipated under any of the proposed alternatives. Alternative 4 would require fewer restrictions to recreational navigation as a result of less surface area requiring engineered caps and subsequent institutional controls, such as restrictions to navigation to prevent disturbance of the cap material.

8.6 Parks, Natural and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves

There are no parks, natural or historical monuments, national seashores, wilderness, research sites, or similar preserves located within the vicinity of the RAB that would be impacted by the proposed alternatives.

9 EVALUATION AND TESTING OF DISCHARGE MATERIAL

Section 2.7 provides a discussion of the discharge material sources and characteristics for the proposed alternatives. The Final EE/CA provides additional information on the evaluation of the sediments in the RAB. Final selection of any engineered cap, habitat layer, and backfill materials included in the proposed alternatives will occur through the design phase.

10 PROPOSED ACTIONS TO MINIMIZE ADVERSE EFFECTS TO THE AQUATIC ENVIRONMENT

Proposed actions to minimize potential adverse effects to the aquatic environment are provided in this section and are discussed in the BA and described in detail in Appendix E of the Final EE/CA.

10.1 General

General actions proposed to minimize the potential adverse effects of the removal action alternatives on the aquatic environment include the following:

- Water quality in the project area will be monitored and compared against all applicable water quality standards to comply with the WQC for the project (including the approved mixing zone in compliance with WAC 173-201A).
- Due to the potential for vessel traffic in the dredging and capping areas, operational controls (as opposed to anchor silt curtains or similar rigid containment devices) are considered the most effective measure for control of turbidity. For example, construction activities can be progressively slowed until turbidity exceedances are no longer detected outside of the compliance boundary to minimize sediment suspension, or dredging cycle times can be decreased to decrease turbidity plumes until the suspended sediment settles.
- In-water work for this project will comply with the timing restrictions specified in the in-water work window, when salmonids, including bull trout, are expected to be either not present or present only in very low numbers. In the LDW, the appropriate in-water work window extends annually from October 1 to February 15; thus, in-water construction activities would occur between these dates.
- Operations will be stopped temporarily if listed species are observed as injured, sick, or dead in the project area to determine whether additional fish are present and to ensure that operations may continue without further impact. NMFS Law Enforcement will be notified, and fish will be handled with care to ensure effective treatment or analysis of cause of death or injury.
- Prior to entering the water, all equipment will be checked for leaks and cleaned of any external petroleum products, hydraulic fluid, coolants, and other deleterious materials.

- A spill containment and control plan will be kept on site during construction activities and will contain notification procedures, specific cleanup and placement instructions for different products, quick response containment, and cleanup measures that will be available, proposed methods for placement of spilled materials, and employee training for spill containment.
- The contractor will establish an Environmental Protection Plan (EPP), which prevents environmental pollution and minimizes environmental degradation during and because of construction operations, including consideration of noise levels, air, water, and land. The EPP will establish and maintain quality control for environmental protection of all proposed actions. Erosion and turbidity control measures will also be included in the EPP.

10.2 Bank Excavation and Containment

Actions proposed to avoid and minimize the potential adverse effects of the removal action alternatives on the aquatic environment from bank excavation and containment activities include the following:

- A sand and gravel habitat layer will be placed on top of the cap armor layer to enhance substrate for benthic invertebrates, which are prey for juvenile salmonids. The habitat material will also fill in the interstitial spaces between the cap armor, which will remove potential hiding places for salmonid predators.
- The slope containment, armor, and habitat layer materials are anticipated to be placed in-the-dry to the extent possible.
- To ensure proper containment placement, in situ cap materials will be placed in a controlled and accurate manner.
- Bathymetry information may be used in deeper areas to verify adequate coverage during and following material placement.
- Sediment containment materials will be imported material that contains chemical concentrations at or below natural background chemical concentrations.
- Surface booms, oil-absorbent pads, and similar materials will be on-site for any sheen that may occur on the surface of the water during construction.
- If there is contaminated excavated material following construction that requires stockpiling and Subtitle D landfill disposal, proper sediment and erosion control

methods will be implemented to contain the material and prevent any material from re-entering the waterway.

10.3 Dredging

Actions proposed to minimize the potential adverse effects of the removal action alternatives on the aquatic environment from dredging activities were developed based on the document *Preliminary Draft – Dredging Methods and Best Management Practices, Duwamish Sediment Other Area and Southwest Bank Corrective Measure* (DOF 2011) submitted by Boeing to EPA in 2011. The methods and BMPs have been identified for the removal action to reduce suspension of sediment into the water column while maintaining productivity. The following subsections summarize the BMPs and rationale presented in Appendix E of the Final EE/CA (Anchor QEA 2011a).

10.3.1 Depth of Contamination Elevation

This BMP involves the following actions:

- Develop an accurate model for depth of contamination (DoC)
- Use the results of the completed sediment coring program, in combination with geospatial analysis, to develop an accurate digital terrain model of the DoC elevation to be removed during dredging

The purpose of the accurately measuring DoC elevation is to accurately characterize the extent of the target material with a high degree of confidence for input into the dredge plan.

10.3.2 Design Dredge Elevation

This BMP involves the following action:

- Use the DoC terrain model, plus an allowance for dredge accuracy and tolerance, to develop an accurate digital terrain model of the design dredge elevation

The purpose of the accurately measuring design dredge elevation is to develop a dredging plan with a high degree of confidence that the target material will be removed efficiently in a single dredging event.

10.3.3 Single Dredging Event

This BMP involves the following action:

- Perform dredging to the design dredge elevation in a single dredge event for each dredge subunit, as verified by periodic bathymetric surveys.

Performing a single dredging event relies on implementation of the design dredge elevation BMP so that each subarea can be dredged to the required elevation, verified with bathymetric surveys, and then immediately covered without the need to wait for results from confirmation chemical testing. This BMP also allows the dredged area to be quickly covered, reducing the potential for ongoing resuspension and release from the loosened residual sediment.

10.3.4 Sand Cover

This BMP involves the following actions:

- Place of a clean sand cover (3 to 6 inches) over dredge cuts in each subunit (size to be determined during the remedy design process) of the site in a timely manner, as soon as practical, after dredging of the subunit is complete.
  - This placement will limit the potential for resuspension and release of sediment from the loosened post-dredging residual material.
- Phase additional backfilling, as appropriate, once all upstream and adjacent dredging is complete.
- The final layer of backfill may be scheduled to occur after all dredging is complete.

10.3.5 Dredging Equipment

This BMP involves the following action:

- Select the appropriate dredging equipment (excavator or derrick) based on the site conditions and accuracy requirements.

10.3.6 Dredging Bucket

This BMP involves the following actions:

- Use an enclosed environmental-type bucket to limit sediment loss and resuspension during dredging activities to the extent possible.

It is likely that a standard clamshell-type bucket will be required for dense or hard sediments, and debris and piling removal.

10.3.7 Dredge Bucket Positioning

This BMP involves the following action:

- Use sub-foot accuracy GPS for accurate bucket positioning.

10.3.8 Stair-Step Dredge Cuts on Slopes

This BMP involves the following action:

- Implement stair-step dredge cuts for steeper slopes to reduce sloughing of sediment.

Implementing stair-step dredge cuts limits the bank sloughing that can occur with deep vertical cuts into the sediment (referred to as "box cuts"). Stair stepping the dredge cuts helps to reduce the formation of generated residuals and reduces the potential for resuspension and release.

10.3.9 Dredge Slopes with Excavator

This BMP involves the following action:

- Use an excavator dredge, as appropriate, for improved bucket control on steeper slopes.

The purpose of dredging steeper slopes using an excavator, as opposed to a cable-deployed bucket, is to limit the disturbance of impacted sediment on the slope during dredging, and, in turn, limit resuspension and release.

10.3.10 Water Management

This BMP involves the following action:

- Prohibit direct overflow of water in sediment haul barges back to the waterway without prior processing and management as dredging return water.

The purpose of the water management BMP is to limit the release of sediment back into the waterway from the sediment haul barge. Implementation of the water management BMP may involve either the active pumping of the excess water from the sediment haul barges or the addition of dewatering agent (for example, Portland cement, lime kiln dust, or diatomaceous earth) to limit the amount of ponded water within the barge and preventing direct overflow from the barge back to the waterway. Failure to manage the water in the barge during dredging can result in the release of turbid water back into the dredged area, with the potential for increased sediment resuspension and release and additional generated residuals.

10.3.11 Intertidal Sediment and Shoreline Bank Soil Removal

This BMP involves the following action:

- Conduct intertidal sediment and shoreline bank soil excavation in-the-dry to the degree reasonably possible using land-based equipment.

Intertidal sediment and shoreline bank soil excavation in-the-dry reduces the potential for release of impacted intertidal sediment and shoreline bank soils to the waterway by removing the sediment accessible from the upland when the tides are out and the sediment is exposed. Low tides during the in-water construction window occur during night hours, although EPA is currently limiting all cleanup activities to occur from 7 a.m. to 6 p.m., with possible extension to 9 p.m. for consistency with the City of Tukwila noise ordinance.

10.3.12 Additional Impact Avoidance and Minimization Measures

Additional measures that will be implemented during dredging to minimize impacts include the following:

- During transport and handling of sediment, adequate containment measures and inspections will be employed to minimize spillage of material into the surface water.
- Bottom or beach stockpiling will be avoided at all times.
- Taking multiple bites with the dredge bucket will be avoided at all times.

- Overfilling of the bucket will be avoided at all times.
- If water quality monitoring identifies parameter measurements above corrective action triggers, dredging rates (time period of dredge and placement cycles) will be regulated, to the extent practicable.
- Standard barge loading controls will be observed, including no barge overfilling. The barge would be loaded so that enough freeboard remains to allow for safe movement of the barge and its material on its planned route.
- Equipment such as fuel hoses, oil drums, and oil or fuel transfer valves and fittings will be checked regularly for drips or leaks and will be maintained to prevent spills to the river.
- All dredge areas will be backfilled to grade with a sand and gravel habitat material except in SMU 4B, which, for navigation purposes, will only require 6 feet of backfill material rather than the 8 feet that are being removed.

10.4 Placement of Cap/Backfill Material

Actions proposed to minimize the potential adverse effects of the Removal Action alternatives on the aquatic environment from placement of cap/backfill material will be the same as those applying to bank excavation and containment.

11 ANALYSIS OF PRACTICABLE ALTERNATIVES

The Final EE/CA presents a complete detailed description and analysis pursuant to the CERCLA criteria of all practicable alternatives considered for the NTCRA (EPA 1993).

This section presents the Final EE/CA recommended removal action alternative for the RAB based on the evaluation of the removal action alternatives presented in Section 7 of the Final EE/CA. The analysis presented in Section 7 of the Final EE/CA shows that three of the removal action alternatives—Alternatives 2, 3, and 4—are each effective and meet project Removal Action Objectives (RAOs) and ARARS. The Final EE/CA determined that Alternative 1 (No Action) was not administratively feasible as it does not provide removal action. These determinations are consistent with the results of the 404(b)(1) Evaluation.

The recommended removal action alternative based on the Final EE/CA analysis is Alternative 4 because it represents the most practical and cost-effective balance of removal and containment while ensuring long-term effectiveness, increasing habitat quality, and minimizing potential long-term Operations and Maintenance (O&M) requirements. Alternative 4 provides the following key advantages:

- Alternatives 2 and 3 have lower short-term risk (this risk reduction would be marginal due to the implementation of conservation measures and engineering controls discussed in Sections 6.2, 6.3, and 6.4) and is less costly than Alternative 4 due to the lower removal volume.
- Alternative 4 was chosen over Alternatives 2 and 3, however, because of the reduction in long-term risk for Alternative 4 due to:
  - Removal of a greater volume of PCB-impacted sediments, resulting in lower risk associated with sediments left in place
  - Elimination of the surface area requiring an engineered cap, lowering the long-term monitoring and maintenance needs (for example, to prevent cap erosion) of the final remedy
  - Reduction in surface area requiring institutional controls to prevent the disturbance of an engineered cap

Although the sediments containing total PCB RvAL exceedances left in place under Alternative 3 can be effectively contained through capping, it was determined that the removal of the complete horizontal and vertical extents of total PCB RvAL exceedances within the RAB would be the preferred alternative based on the issues noted. Figure 6 provides the cross-section view of Alternative 4, the preferred alternative.

12 FACTUAL DETERMINATIONS

The Final EE/CA alternatives analysis determined that the removal of the complete horizontal and vertical extents of total PCB RvAL exceedances within the RAB would be the preferred alternative. Based on the project purpose and need described in Section 2 of this document and the impacts described in sections 5 through 8, this section provides the factual determination of the least environmentally damaging practicable alternative.

12.1 Physical Substrate Determinations

Under the proposed Action Alternatives 2, 3, and 4, dredging is proposed for the sediments with the highest chemical concentrations that can be practicably dredged. Capping will be conducted where contaminant depths are too great for dredging to be effectively and practicably implemented or where contaminant concentrations are marginally elevated but still need to be addressed. Implementation of these actions will result in alteration of physical substrates. These alterations are judged environmentally beneficial because elevated chemical concentrations in exposed sediments will be significantly reduced, and sediments in capped areas will be immobilized; however, Alternative 4 removes a greater volume of PCB-impacted sediments, resulting in lowering risk and meeting the project's stated purpose and need. Further, the lack of capping area eliminated long-term monitoring and institutional controls required to ensure the stability and integrity of an engineered cap. *Therefore, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.2 Water Circulation and Fluctuation Determinations

Dredging and capping/backfilling activities proposed under Action Alternatives 2, 3, and 4 are not expected to disrupt current patterns and water circulation at the RAB or in the LDW, either during or after construction. Based on the overall ability to meet the project's purpose and need as demonstrated in the Final EE/CA and because the alternatives were determined to have insignificant impacts to this component of the aquatic environment, *Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.3 Suspended Particulate Materials and Turbidity Determinations

The proposed dredging and discharge of cap/backfill materials under Alternatives 2, 3, and 4 are expected to result in some short-term and localized increases in turbidity. These would be most likely to occur close to where dredging or capping/backfilling activities are occurring. These potential effects would be mitigated by monitoring water quality in appropriate locations and implementing BMPs to reduce turbidity if it exceeds acceptable levels. A water quality monitoring plan and a plan for implementing BMPs will be developed during the design phase. The proposed actions under Alternatives 2, 3, and 4 will improve water quality in the long term and provide a net benefit to aquatic resources. The project would implement the BMPs and controls discussed in Section 10 and Appendix E of the Final EE/CA to minimize any potential impacts related to suspended particulate materials and turbidity. Although dredging has the potential to generate more turbidity than capping due to the amount of material disturbed, removal of complete horizontal and vertical extents of total PCB exceedances is most consistent with the project purpose and need. *Therefore, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.4 Contaminant Determinations

The proposed Alternatives 2, 3, and 4 will greatly reduce or remove elevated chemical concentrations identified in the RAB sediments. Removal of these materials and the discharge of clean fill materials will provide a new, clean bed surface that will significantly reduce exposure of ecological and human receptors to potentially toxic concentrations of contaminants. It is anticipated that all of the proposed alternatives will comply with water quality criteria established for the project, pursuant to the mixing zone standards in WAC 173-210A. The mixing zone will consider a reasonably sufficient distance to allow for potential temporary water quality exceedances to occur and resolve. Areas outside of the mixing zone must be in compliance with the criteria defined in the WQC. It is expected that the mixing zone for this project will extend 300 feet radially from the work area.

Although the sediments containing total PCB RvAL exceedances left in place under Alternative 3 can be effectively contained through capping, it was determined that it was preferable to meet the project purpose and need by completely removing the horizontal and vertical extents of total PCB RvAL exceedances within the RAB in order to minimize the long-term risk. *Therefore, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.5 Aquatic Ecosystem and Organism Determinations

The dredging and capping/backfilling activities associated with Alternatives 2, 3, and 4 may have temporary and localized adverse impacts on the aquatic ecosystem and organisms. Slope excavation will result in the creation of a small amount of intertidal area due to shallowing of the slope. Dredging and discharge of fill materials for capping/backfilling activities will temporarily impact existing benthic invertebrate communities and disrupt fish access to the project area during implementation of the removal action. Capping/backfill material will provide clean substrates that will be quickly recolonized by benthic invertebrates. It is expected that the long-term reduction of exposure to elevated chemical concentrations will provide a significant improvement over existing conditions for the aquatic ecosystem and organisms as the result of the proposed removal action alternatives. Alternative 4 includes removal of a greater volume of PCB-impacted sediments, resulting in lower risk than with contaminants capped in place and was determined through the EE/CA process to be the preferred alternative. *Therefore, because it was identified as the most able to meet the project's stated purpose and need, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.6 Determination of Cumulative Impacts on the Aquatic Ecosystem

As defined in 40 CFR 230.11(g)(1), cumulative impacts are the changes in the aquatic ecosystem that are attributable to the collective effect of a number of individual discharges of dredged or fill material into waters of the United States. Although the impact of a particular discharge may constitute a minor change in itself, the cumulative effect of numerous discharges in an area can result in a major impairment of the water resources and interfere with the productivity and water quality of the existing ecosystem.

The proposed Boeing clean-up action is expected, per the Memorandum of Agreement (MOA) between EMJ and Boeing, to occur concurrently with the cleanup action at the Facility in order to achieve cleanup goals and reduce the likelihood of recontamination at either site. The remainder of the LDW Superfund Site cleanup is slated to occur in future years, with the intent and expectation of providing a net benefit to species and habitat through cleanup of contaminated sediments throughout the estuary. These cleanup actions are anticipated to include additional individual discharges of fill materials in the LDW. In addition, mitigation activities may occur related to other cleanup actions in order to ensure substantive compliance with Section 404(b)(1), and restoration actions under the Natural Resource Damages Assessment process may also occur in the area. The improvement of habitat quality and ecosystem function because of complete removal of the contaminated sediments under Alternative 4 will achieve the project purpose and result in a long-term benefit to the aquatic system. *Therefore, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

12.7 Determination of Secondary Impacts on the Aquatic Ecosystem

Secondary effects are effects on the aquatic ecosystem that are associated with actions that are removed in time and possibly distance from the action (e.g., discharge of dredged or fill materials [the direct impact]), and do not occur directly from the action (40 CFR 230.11(h)(1)). Under CWA, secondary impacts analyses do not extend beyond the aquatic environment (40 CFR 230). Therefore, secondary impacts are limited to other actions in the aquatic environment such as erosion or downstream sedimentation or compensatory mitigation.

As in Section 5 of this document, it has been determined that the implementation of the preferred alternative would have a negligible impact on substrate conditions or water circulation and flow patterns. It is similarly assumed that implementation of the preferred alternative would not be attributable to erosion or downstream sedimentation, as these processes operate over a much larger scale in the watershed.

The intent of undertaking the preferred alternative is to reduce risks to human health and the environment posed by contaminated sediments. The preferred alternative does not require specific compensatory mitigation to be in compliance with Section 404(b)(1) because it does not result in a significant long-term loss of aquatic habitat and actually includes creation of new shallow intertidal habitat as part of the slope reconfiguration action. In summary, it is unlikely that the implementation of the preferred alternative would directly cause other significant actions to occur that would affect the aquatic environment in the RAB. *Therefore, Alternative 4 is determined to be the least environmentally damaging, practicable alternative.*

13 DETERMINATION OF INCLUSION OF ALL APPROPRIATE AND PRACTICABLE MEASURES TO MINIMIZE POTENTIAL HARM ON THE AQUATIC ECOSYSTEM

In evaluating a specific discharge, EPA is required to examine other practicable alternatives to the proposed discharge, which may include not discharging or discharging at a different aquatic site (40 CFR § 230.5). The guidelines state that discharge of dredge or fill material is not permitted, "if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (40 CFR § 230.10[a]). An alternative is considered practicable, "if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." That is, if there are locations or suitable methods that meet the overall project purposes and do not have other significant adverse environmental consequences, then the least environmentally damaging option will be the highest priority for selection if it is demonstrated to meet the project purpose and need.

Preliminary conservation measures that should be considered in developing the final plan to minimize construction impacts were presented Section 10.

13.1 Other Locations

The removal action alternatives have been designed to address very site-specific contamination issues within the RAB. Each of the alternatives address risk in the RAB with different combinations of dredging and capping. The remediation is based on specific locations of sediment that exceed screening criteria. For the remediation to be effective, the materials in the caps must be placed in the area of contamination. Similarly, areas identified for sediment removal would require removal and placement of the residual layer in exactly the same location. Therefore, other locations are not practicable.

Several disposal locations and treatment options for dredged material are considered in the Section 5 of the Final EE/CA. The Final EE/CA did not retain treatment as an option for further consideration due to concerns related to implementability, effectiveness, and cost. On-site disposal was also not considered viable due to timeframe, land availability constraints, and overall habitat impacts. Off-site disposal at a permitted Subtitle D landfill was considered to be a practicable alternative for the removal action; in-water filling was not considered applicable.

13.2 Practicable Alternatives

The Final EE/CA determination of practicable alternatives is discussed in Section 11 of this document.

14 REVIEW OF CONDITIONS FOR COMPLIANCE

The potential for significant adverse impacts on the aquatic ecosystem resulting from implementation of Alternative 4 are mitigated to the extent possible through the application of avoidance and minimization measures described in Section 10.0. According to the guidance, "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences" (40 CFR 230.10 (a).

14.1 Availability of Practicable Alternatives

A practicable alternative according to 40 CFR 230.10 is available and capable of being conducted after taking into consideration cost, existing technology, and logistics in light of the overall project purpose and need.

Activities that do not involve a discharge of material into waters of the United States (e.g., LDW) include Alternative 1 (No Action). However, according to the purpose and need of the removal action, this alternative is not considered to be available per 40 CFR 230.10. The proposed Alternatives 2 through 4 do not involve discharge into special aquatic sites; therefore, under 40 CFR 230.10(3), all of the alternatives are considered to be available.

The Final EE/CA alternatives analysis determined, based upon review of the nine CERCLA criteria and the ARARs identified for the site, that Alternative 4 was the most practicable alternative best able to achieve the risk reduction goals of the remediation.

14.2 Compliance with Pertinent Legislation

The preferred alternative activities within the LDW Superfund Site must comply with the substance of any identified legally applicable requirement to the extent practical or receive an ARAR waiver allowed by EPA guidance under certain circumstances. Federal and State of Washington potential ARARs are compiled and used as evaluation criteria for the removal alternatives in the EE/CA evaluation. Table 4-1 of the Final EE/CA includes all potential ARARs for the proposed removal action alternatives. Removal action activities do not have to comply with the corresponding procedural requirements, such as permit applications, reporting obligations, and record keeping requirement but must comply with all substantive and procedural legally applicable requirements.

14.3 Potential for Significant Degradation of Waters of the United States as a Result of the Discharge of Polluted Materials

Due to proposed methods of construction, measures to minimize water quality effects, and RAB existing conditions, the potential for long-term degradation of the waters of the United States because of the discharges evaluated here is considered unlikely. In fact, the objectives of the action are to minimize degradation of the water through removal or isolation of sediments with elevated chemical concentrations. Short-term water quality effects during construction are anticipated and are expected to be minor and localized in nature. EPA received comments during the public review process of the Final EE/CA requesting further information regarding specific technologies and BMPs that will be used to minimize significant in-water releases of suspended sediments during dredging completed as part of the EE/CA removal action. Appendix E to the Final EE/CA describes the proposed dredging methods and the types of BMPs that will be used to reduce the suspension of sediments during in-water removal activities for the preferred alternative.

Based on the effectiveness evaluation of technologies presented in Appendix E, the preferred alternative will use mechanical dredging using an excavator with an articulated, enclosed bucket. In areas where this type of bucket is unable to remove large debris, a heavier bucket with digging capabilities or a conventional wire-supported clamshell dredge, grapple, or vibratory hammer would be required. The proposed removal technology, along with the implementation of the specific BMPs outlined in Appendix E, will provide additional assurances again degradation of waters of the United States.

14.4 Steps to Minimize Potential Adverse Impacts on the Aquatic Ecosystem

Section 10 of this document and Appendix E of the Final EE/CA include effects minimization actions and conservation measures designed to reduce potential effects of the activities and construction methods that will be employed in the implementation of the preferred alternative.

15 FINDINGS

Although undertaking Alternatives 2 or 3 were demonstrated to have lower short-term risks, and, therefore, would result in reduced impacts to the aquatic environment during construction, Alternative 4 was chosen over Alternatives 2 and 3 because of the reduction in long-term risk due to removal of a greater volume of PCB-impacted sediments, resulting in lower risk associated with sediments left in place. Further, Alternative 4 provides lower long-term monitoring and maintenance needs (for example, to prevent cap erosion) of the final remedy through elimination of surface area requiring an engineered cap. The small increase in short-term impacts of Alternative 4 was considered negligible when considering the risk reduction achieved through complete removal of impacted sediments, which is an integral component of the project's stated purpose and need. Therefore, Alternative 4 best achieves the overall project purpose and need for reducing risk to the environment and public health while maintaining the aquatic-dependent use of the RAB. As previously discussed, the project includes a number of measures to avoid and minimize impacts resulting from discharges of fill in the RAB, and the slope reconfiguration will result in an increase in intertidal habitat. For these reasons, Alternative 4 is the least environmentally damaging practicable alternative.

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FIGURES

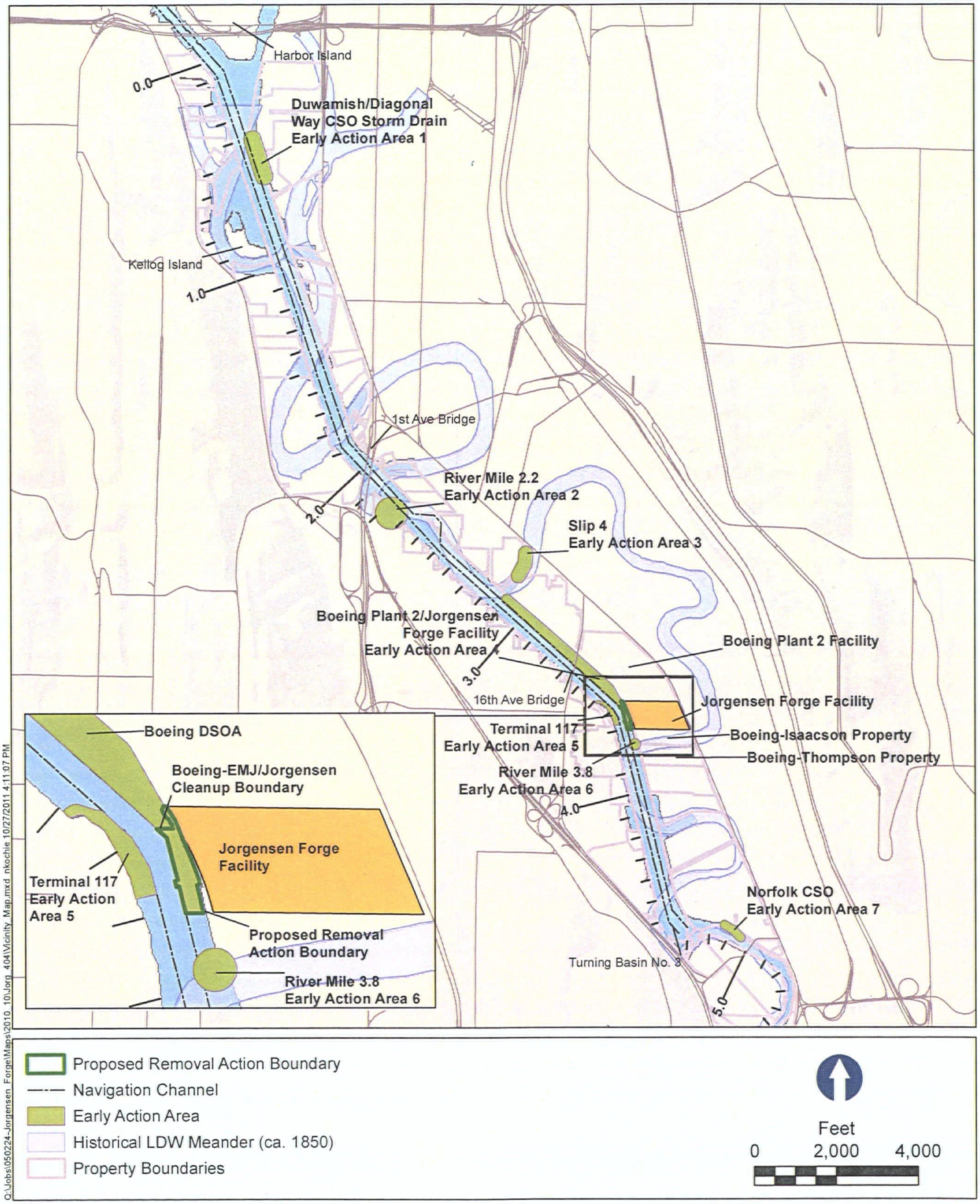

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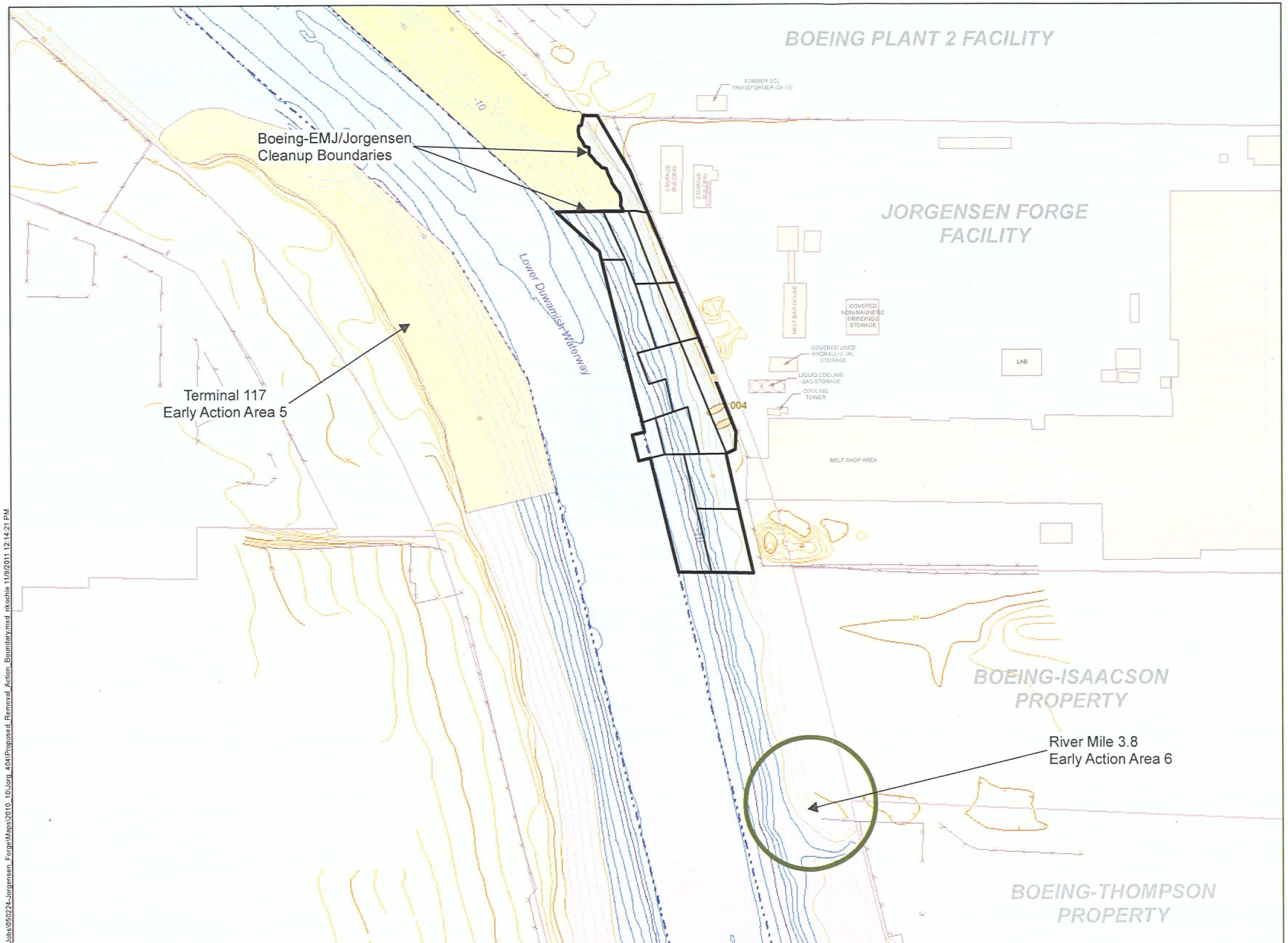
Figure 1
Facility Vicinity Map
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



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LEGEND

- Sediment Management Unit Boundary
- Fences
- Federal Navigation Channel
- Removal Action Boundary
- Debris Pile
- Property Boundaries
- Boeing DSOA
- Terminal 117 Early Action Area 5 Boundary

NOTES:

1. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).

2. Outfall locations field identified on May 14, 2003.

3. The toe of the riprap slope, inactive 24-inch and 12-inch Boeing property line outfalls were surveyed during a low tide on August 28, 2008.

4. The Boeing-EMJ/Jorgensen cleanup boundary identified in the Memorandum of Understanding between Boeing and EMJ/Jorgensen Forge, dated August 2007. (EMJ et al. 2007)

Feet

0 80 160 240 320

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Figure 2
Removal Action Boundary
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility

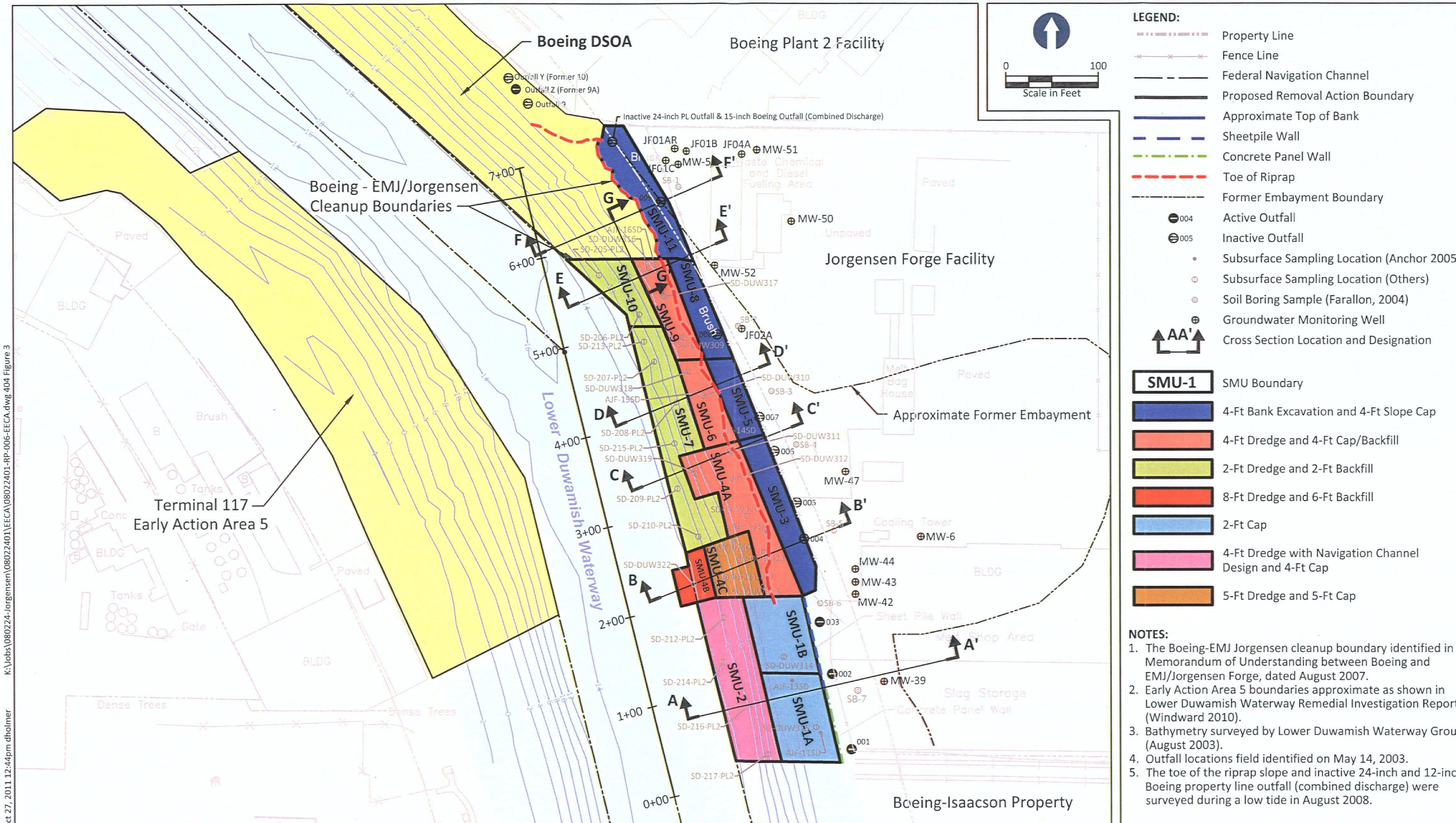

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Figure 3
Alternative 2 Site Plan
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility

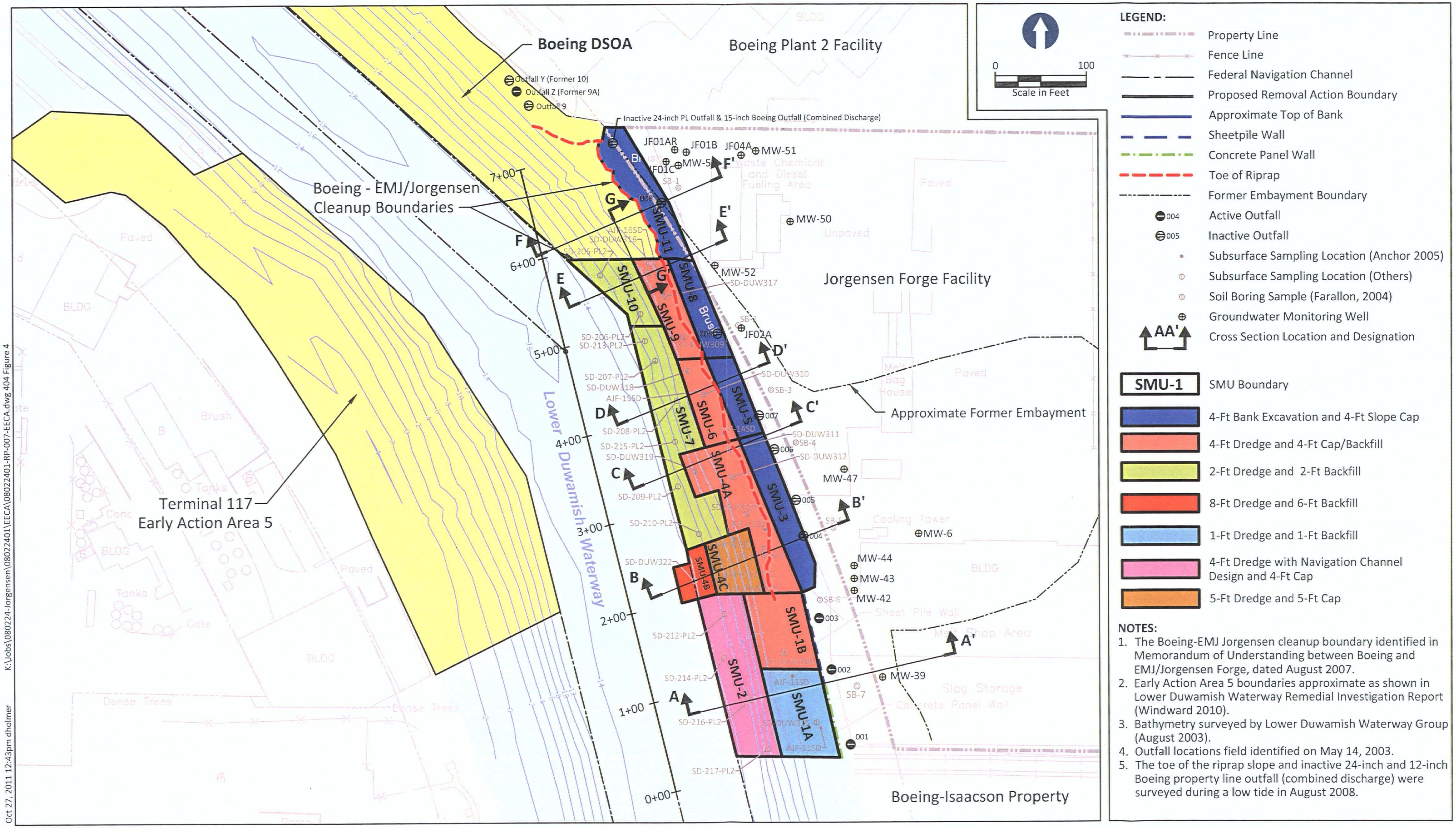

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Figure 4
Alternative 3 Site Plan
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility

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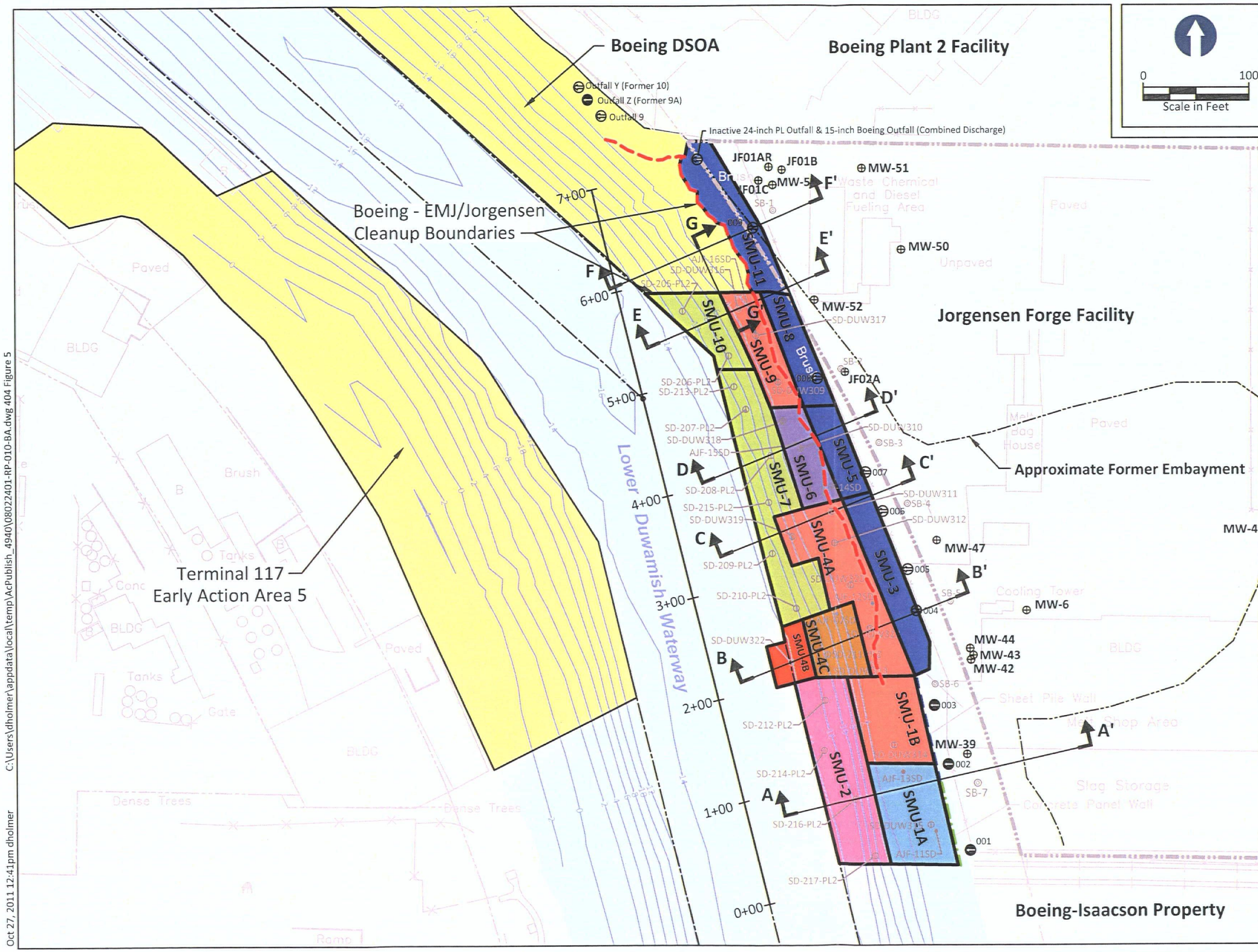

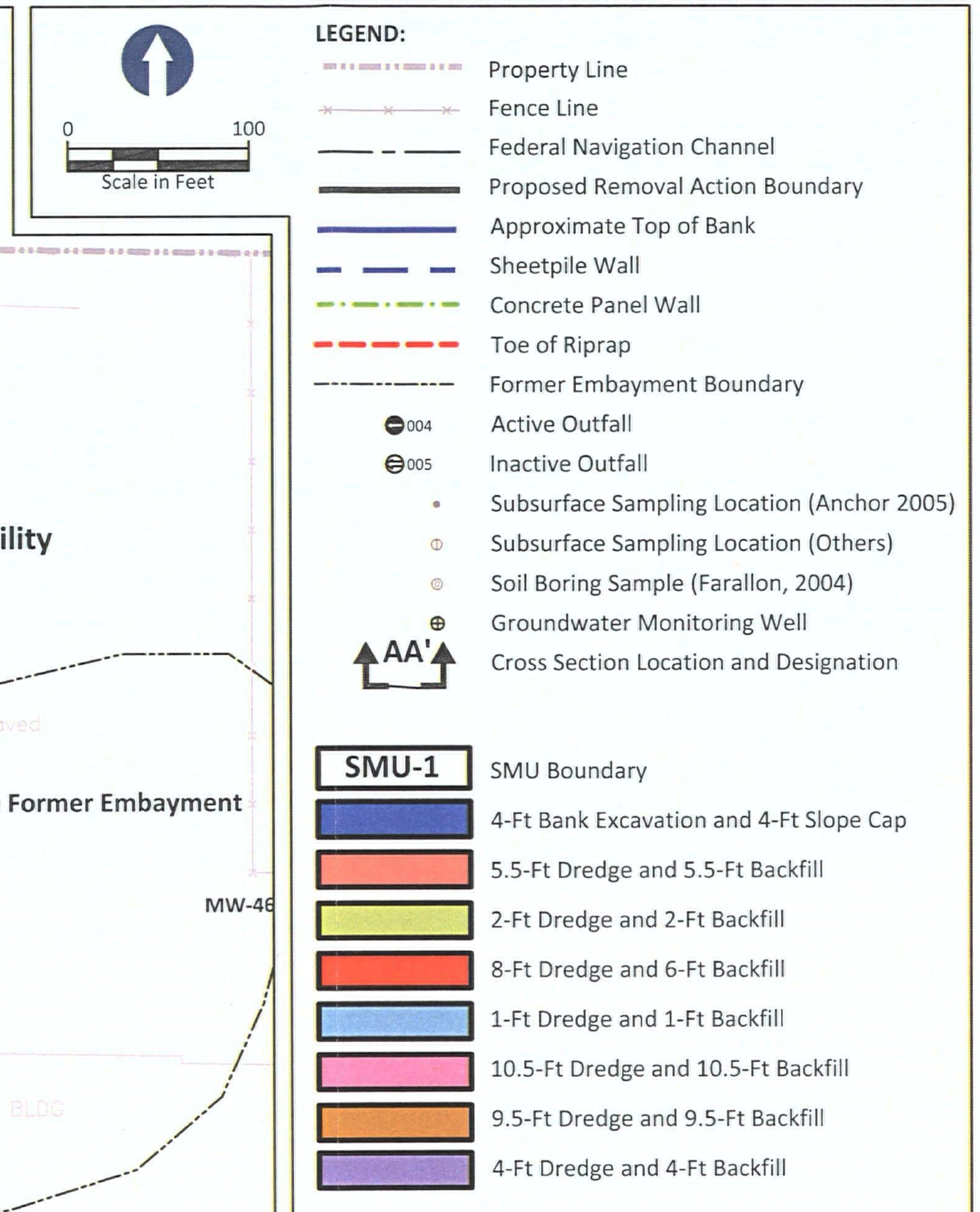

NOTES:
1. The Boeing-EMJ Jorgensen cleanup boundary identified in Memorandum of Understanding between Boeing and EMJ/Jorgensen Forge, dated August 2007.
2. Early Action Area 5 boundaries approximate as shown in Lower Duwamish Waterway Remedial Investigation Report (Windward 2010).
3. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
4. Outfall locations field identified on May 14, 2003.
5. The toe of the riprap slope and inactive 24-inch and 12-inch Boeing property line outfall (combined discharge) were surveyed during a low tide in August 2008.

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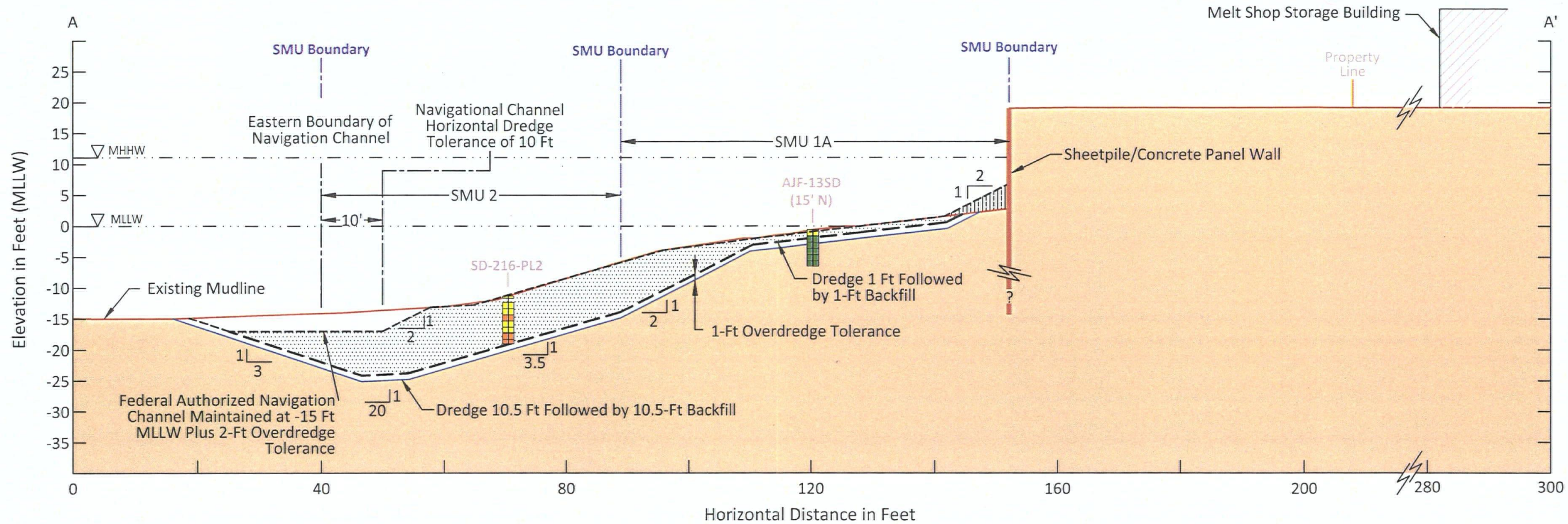
Figure 5
Preferred Alternative Site Plan
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section A-A'

(Looking Downstream)

LEGEND:

SD-DUW310 — Core Sample Identification
(2' S) — Offset Distance in Feet
Core Sample Location
Sample Interval in Feet

Greatest Concentration of Total PCBs and Metals Relative to SMS Criteria:

- <0.5 x SQS/LAET (<6 mg/kg OC or <65 µg/kg)
- 0.5 x SQS/LAET - SQS/LAET (6 -12 mg/kg OC or 65 µg/kg - 130 µg/kg)
- SQS/2LAET - CSL/2LAET (12 - 65 mg/kg OC or 130 µg/kg - 1000 µg/kg)
- CSL/2LAET - 2xCSL/2LAET (65 - 130 mg/kg OC or 1000 µg/kg - 2000 µg/kg)
- 2xCSL/2LAET (>130 mg/kg OC or >2000 µg/kg)
- Non-Detect Greater than the SQS/LAET Criteria (>12 mg/kg OC or >130 µg/kg)
- Sample Not Taken

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Backfilled
- Volume to be Backfilled

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. Federally authorized navigation channel last dredged at this location in 1999.
3. Sediment samples were OC-normalized and compared to SQS and CSL Total PCBs criteria. Sediment samples with TOC <0.5% or TOC >3% were not OC-normalized and were compared to LAET and 2LAET Total PCBs criteria.
4. Backfill material proposed in navigation channel to achieve stable slopes following removal outside the channel. No capping proposed in the navigation channel.
5. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
6. Subsurface sediment data queried from LDWG database (July 2010).
7. Sediment Quality Standard (SQS) = 12 mg/kg OC
8. Cleanup Screening Level (CSL) = 65 mg/kg OC
9. Lowest Apparent Effects Threshold (LAET) = 130 µg/kg
10. Second Lowest Apparent Effects Threshold (2LAET) = 1000 µg/kg
11. Mean lower low water elevation = MLLW
12. Mean higher high water elevation = MHHW

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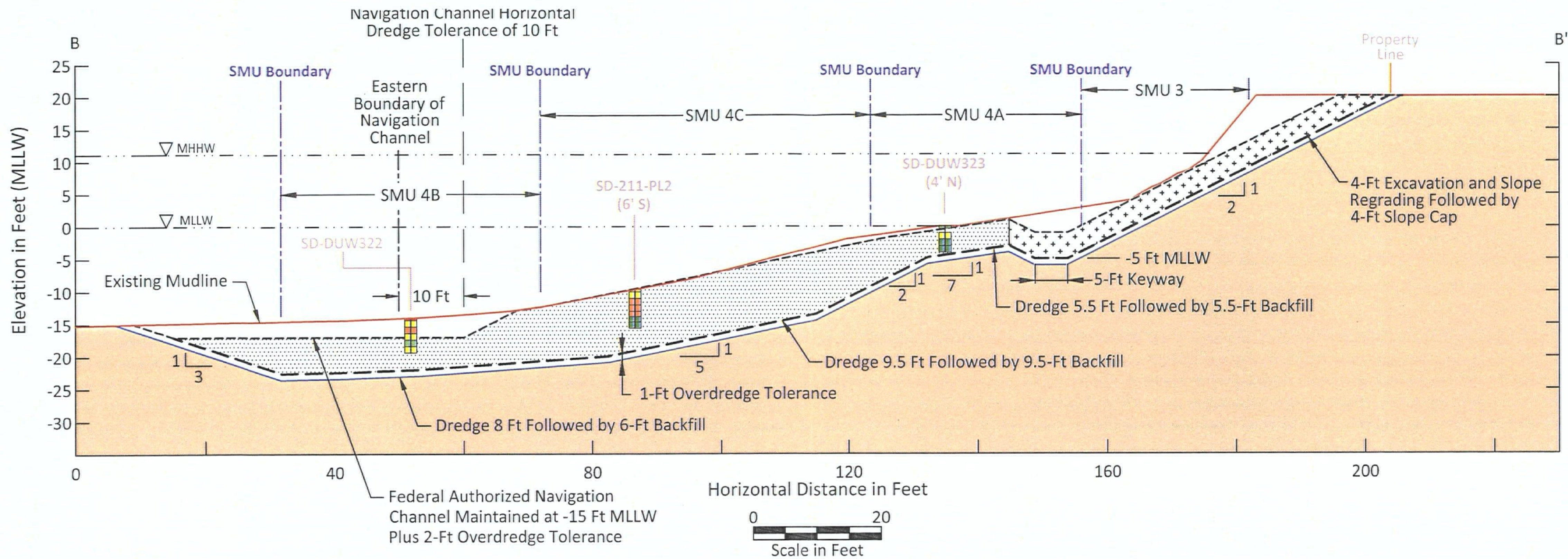
Figure 6a
Preferred Alternative Cross Section A-A'
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section B-B'

(Looking Downstream)

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. Federally authorized navigation channel last dredged at this location in 1999.
3. Sediment samples were OC-normalized and compared to SQS and CSL Total PCBs criteria. Sediment samples with TOC <0.5% or TOC >3% were not OC-normalized and were compared to LAET and 2LAET Total PCBs criteria.
4. Cap versus backfill designation to be determined based on sediment concentrations at bottom of designed removal elevation plus overdredge tolerance.
5. Backfill material proposed in navigation channel to achieve stable slopes following removal outside the channel. No capping proposed in the navigation channel.
6. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
7. Subsurface sediment data queried from LDWG database (July 2010).
8. Sediment Quality Standard (SQS) = 12 mg/kg OC
9. Cleanup Screening Level (CSL) = 65 mg/kg OC
10. Lowest Apparent Effects Threshold (LAET) = 130 µg/kg
11. Second Lowest Apparent Effects Threshold (2LAET) = 1000 µg/kg
12. Mean lower low water elevation = MLLW
13. Mean higher high water elevation = MHHW

LEGEND:

SD-DUW310 Core Sample Identification
(2' S) Offset Distance in Feet
Core Sample Location
Sample Interval in Feet

Greatest Concentration of Total PCBs and Metals Relative to SMS Criteria:

- <0.5 x SQS/LAET (<6 mg/kg OC or <65 µg/kg)
- 0.5 x SQS/LAET - SQS/LAET (6 -12 mg/kg OC or 65 µg/kg - 130 µg/kg)
- SQS/2LAET - CSL/2LAET (12 - 65 mg/kg OC or 130 µg/kg - 1000 µg/kg)
- CSL/2LAET - 2xCSL/2LAET (65 - 130 mg/kg OC or 1000 µg/kg - 2000 µg/kg)
- 2xCSL/2LAET (>130 mg/kg OC or >2000 µg/kg)
- Non-Detect Greater than the SQS/LAET Criteria (>12 mg/kg OC or >130 µg/kg)
- Sample Not Taken

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Backfilled
- Volume to be Excavated and Capped

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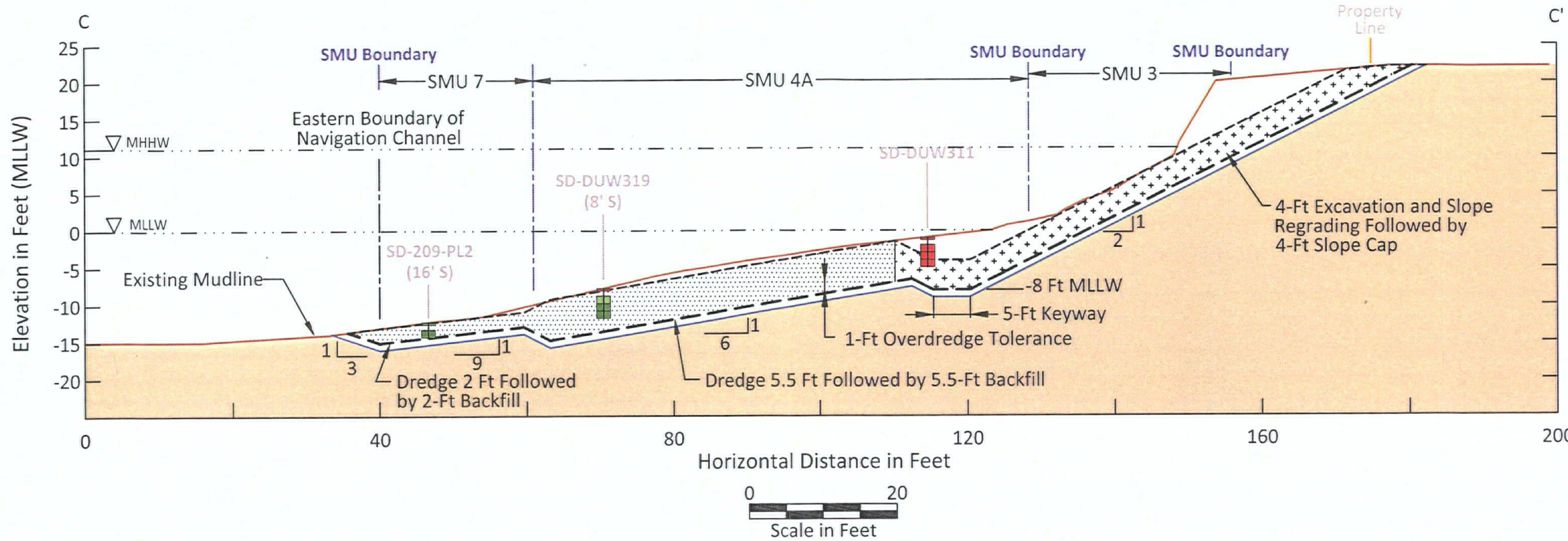
Figure 6b

Preferred Alternative Cross Section B-B'
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section C-C'
(Looking Downstream)

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. Federally authorized navigation channel last dredged at this location in 1999.
3. Sediment samples were OC-normalized and compared to SQS and CSL Total PCBs criteria. Sediment samples with TOC <0.5% or TOC >3% were not OC-normalized and were compared to LAET and 2LAET Total PCBs criteria.
4. Cap versus backfill designation to be determined based on sediment concentrations at bottom of designed removal elevation plus overdredge tolerance.
5. Backfill material proposed in navigation channel to achieve stable slopes following removal outside the channel. No capping proposed in the navigation channel.
6. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
7. Subsurface sediment data queried from LDWG database (July 2010).
8. Sediment Quality Standard (SQS) = 12 mg/kg OC
9. Cleanup Screening Level (CSL) = 65 mg/kg OC
10. Lowest Apparent Effects Threshold (LAET) = 130 µg/kg
11. Second Lowest Apparent Effects Threshold (2LAET) = 1000 µg/kg
12. Mean lower low water elevation = MLLW
13. Mean higher high water elevation = MHHW

LEGEND:

SD-DUW310 (2' S) — Core Sample Identification; Offset Distance in Feet
Core Sample Location
Sample Interval in Feet

Greatest Concentration of Total PCBs and Metals Relative to SMS Criteria:

- <0.5 x SQS/LAET (<6 mg/kg OC or <65 µg/kg)
- 0.5 x SQS/LAET - SQS/LAET (6 -12 mg/kg OC or 65 µg/kg - 130 µg/kg)
- SQS/2LAET - CSL/2LAET (12 - 65 mg/kg OC or 130 µg/kg - 1000 µg/kg)
- CSL/2LAET - 2xCSL/2LAET (65 - 130 mg/kg OC or 1000 µg/kg - 2000 µg/kg)
- 2xCSL/2LAET (>130 mg/kg OC or >2000 µg/kg)
- Non-Detect Greater than the SQS/LAET Criteria (>12 mg/kg OC or >130 µg/kg)
- Sample Not Taken

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Backfilled
- Volume to be Excavated and Capped

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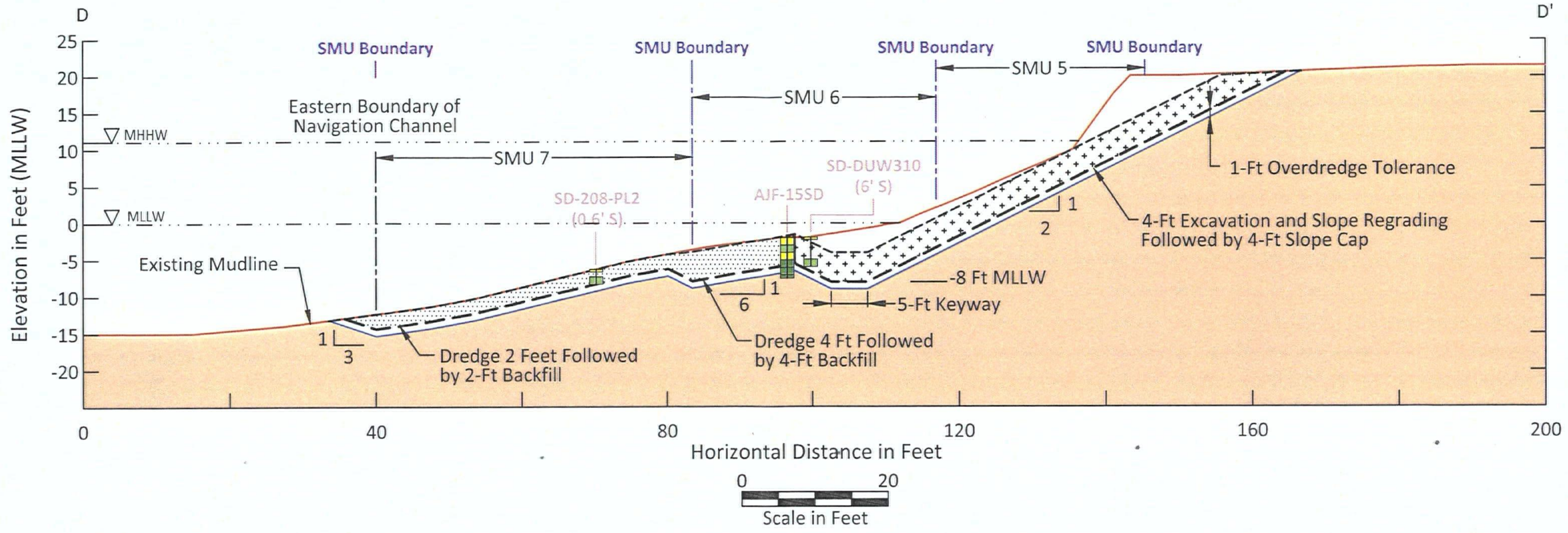
Figure 6c
Preferred Alternative Cross Section C-C'
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section D-D'

(Looking Downstream)

LEGEND:

- SD-DUW310 (2' S) — Core Sample Identification; Offset Distance in Feet
- Core Sample Location
- Sample Interval in Feet

Greatest Concentration of Total PCBs and Metals Relative to SMS Criteria:

- <0.5 x SQS/LAET (<6 mg/kg OC or <65 µg/kg)
- 0.5 x SQS/LAET - SQS/LAET (6 -12 mg/kg OC or 65 µg/kg - 130 µg/kg)
- SQS/2LAET - CSL/2LAET (12 - 65 mg/kg OC or 130 µg/kg - 1000 µg/kg)
- CSL/2LAET - 2xCSL/2LAET (65 - 130 mg/kg OC or 1000 µg/kg - 2000 µg/kg)
- 2xCSL/2LAET (>130 mg/kg OC or >2000 µg/kg)
- Non-Detect Greater than the SQS/LAET Criteria (>12 mg/kg OC or >130 µg/kg)
- Sample Not Taken

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Backfilled
- Volume to be Excavated and Capped

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. Federally authorized navigation channel last dredged at this location in 1999.
3. Sediment samples were OC-normalized and compared to SQS and CSL Total PCBs criteria. Sediment samples with TOC <0.5% or TOC >3% were not OC-normalized and were compared to LAET and 2LAET Total PCBs criteria.
4. Backfill material proposed in navigation channel to achieve stable slopes following removal outside the channel. No capping proposed in the navigation channel.
5. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
6. Subsurface sediment data queried from LDWG database (July 2010).
7. Sediment Quality Standard (SQS) = 12 mg/kg OC
8. Cleanup Screening Level (CSL) = 65 mg/kg OC
9. Lowest Apparent Effects Threshold (LAET) = 130 µg/kg
10. Second Lowest Apparent Effects Threshold (2LAET) = 1000 µg/kg
11. Mean lower low water elevation = MLLW
12. Mean higher high water elevation = MHHW

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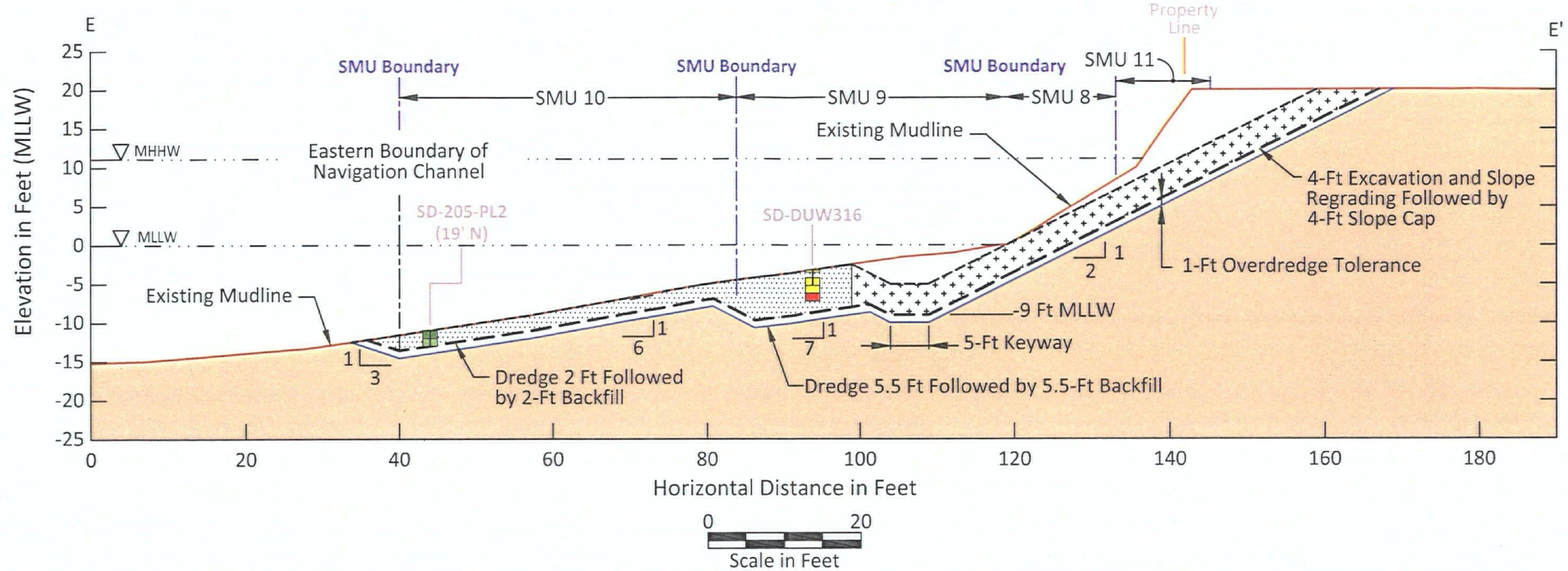
Figure 6d
Preferred Alternative Cross Section D-D'
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section E-E'

(Looking Downstream)

LEGEND:

SD-DUW310 (2' S) — Core Sample Identification, Offset Distance in Feet

Core Sample Location

Sample Interval in Feet

Greatest Concentration of Total PCBs and Metals Relative to SMS Criteria:

- <0.5 x SQS/LAET (<6 mg/kg OC or <65 µg/kg)
- 0.5 x SQS/LAET - SQS/LAET (6 -12 mg/kg OC or 65 µg/kg - 130 µg/kg)
- SQS/2LAET - CSL/2LAET (12 - 65 mg/kg OC or 130 µg/kg - 1000 µg/kg)
- CSL/2LAET - 2xCSL/2LAET (65 - 130 mg/kg OC or 1000 µg/kg - 2000 µg/kg)
- 2xCSL/2LAET (>130 mg/kg OC or >2000 µg/kg)
- Non-Detect Greater than the SQS/LAET Criteria (>12 mg/kg OC or >130 µg/kg)
- Sample Not Taken

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Backfilled
- Volume to be Excavated and Capped

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. Federally authorized navigation channel last dredged at this location in 1999.
3. Sediment samples were OC-normalized and compared to SQS and CSL Total PCBs criteria. Sediment samples with TOC <0.5% or TOC >3% were not OC-normalized and were compared to LAET and 2LAET Total PCBs criteria.
4. Cap versus backfill designation to be determined based on sediment concentrations at bottom of designed removal elevation plus overdredge tolerance.
5. Backfill material proposed in navigation channel to achieve stable slopes following removal outside the channel. No capping proposed in the navigation channel.
6. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
7. Subsurface sediment data queried from LDWG database (July 2010).
8. Sediment Quality Standard (SQS) = 12 mg/kg OC
9. Cleanup Screening Level (CSL) = 65 mg/kg OC
10. Lowest Apparent Effects Threshold (LAET) = 130 µg/kg
11. Second Lowest Apparent Effects Threshold (2LAET) = 1000 µg/kg
12. Mean lower low water elevation = MLLW
13. Mean higher high water elevation = MHHW

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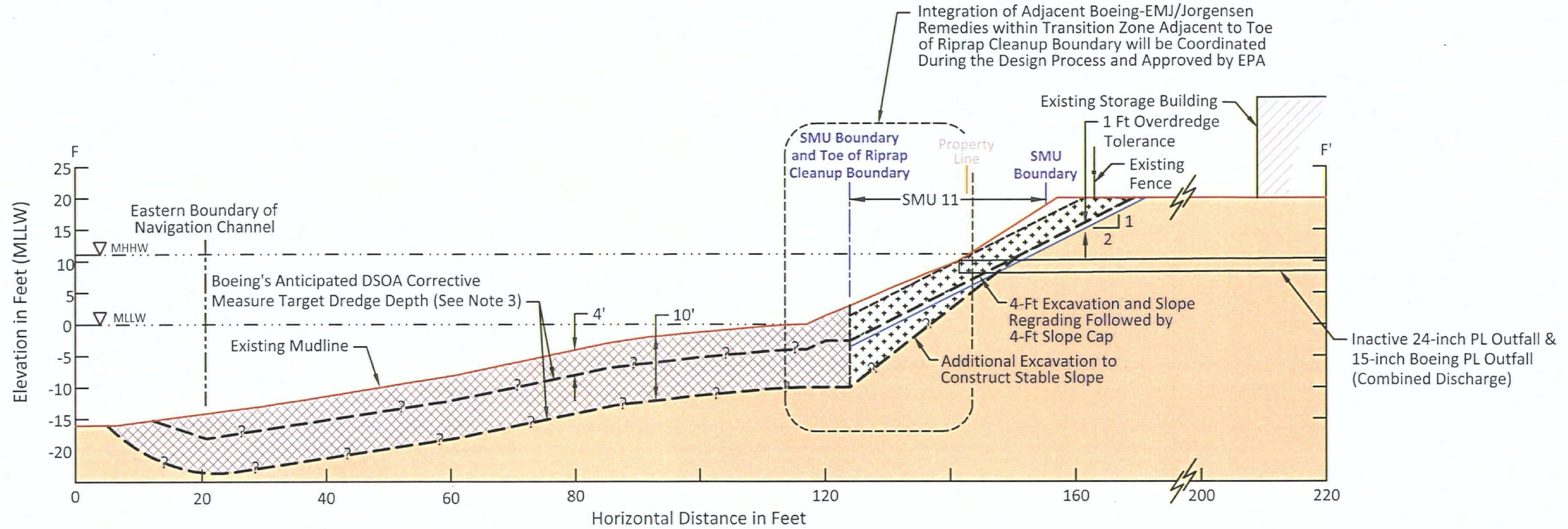
Figure 6e

Preferred Alternative Cross Section E-E'

Early Action Area 4 404(b)(1) Evaluation

Jorgensen Forge Facility



Cross Section F-F'

(Looking Downstream)

LEGEND:

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Overdredge Limit
- Volume to be Dredged and Capped/Backfilled
- Volume to be Excavated and Capped

NOTES:

1. Engineered cap to include isolation layer, erosion protection and habitat mix. Erosion protection requirements will vary by location, as determined during design.
2. The cleanup boundary between the adjacent Boeing and EMJ/Jorgensen remedies is the toe of riprap elevation. This elevation was surveyed by Boeing and EMJ/Jorgensen representatives during a low tide in August 2008.
3. The Boeing corrective measure is currently being reviewed by EPA. Therefore, the depth of removal and subsequent cap/backfill depth is unknown. The Boeing ACMER, dated December 2010, requires remedial alternatives that are anticipated to remove between 4 to 10 ft in the DSOA. This range of removal depths is shown here for illustrative purposes. The integration of the adjacent remedies at the toe of the riprap will occur during the design phase and be approved by EPA.
4. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
5. Mean lower low water elevation = MLLW
6. Mean higher high water elevation = MHHW

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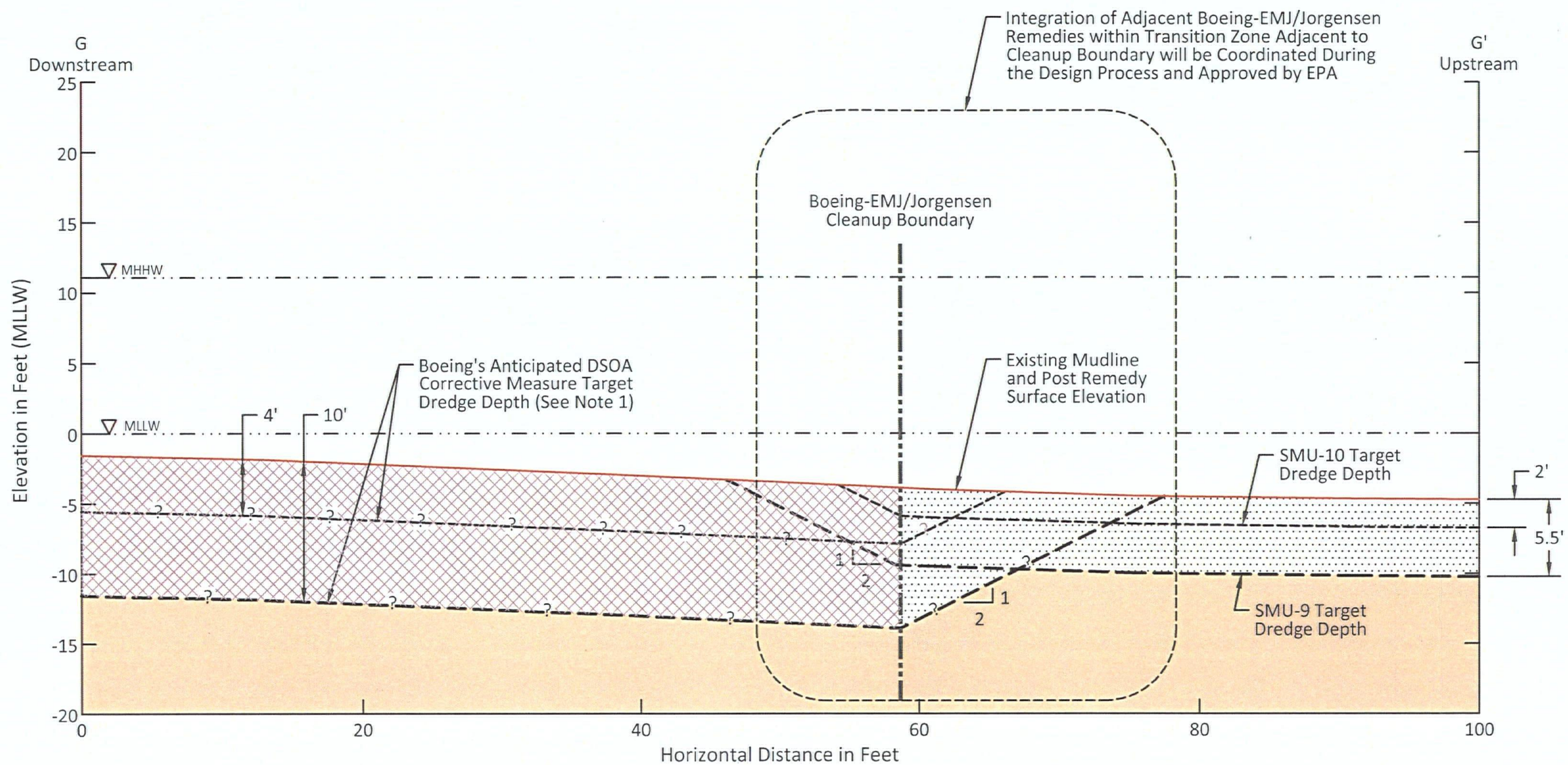
Figure 6f
Preferred Alternative Cross Section F-F'
Early Action Area 4 404(b)(1) Evaluation
Jorgensen Forge Facility



Cross Section G-G'

(Looking Shoreward)

LEGEND:

- Existing Mudline
- Post-Construction Grade
- Excavation Limit
- Volume to be Dredged and Capped/Backfilled
- Volume to be Dredged and Backfilled

NOTES:

1. The Boeing corrective measure is currently being reviewed by EPA. Therefore, the depth of removal and subsequent cap/backfill depth is unknown. The Boeing ACMER, dated December 2010, requires remedial alternatives that are anticipated to remove between 4 to 10 ft in the DSOA. This range of removal depths is shown here for illustrative purposes. The integration of the adjacent remedies at the toe of the riprap will occur during the design phase and be approved by EPA.
2. Cap or backfill material will be placed following dredging to return mudline elevations to existing elevations. Surface material will be sized based on an evaluation of erosion potential.
3. The 2H:1V slopes shown extending from the Boeing-EMJ/Jorgensen cleanup boundary represent the anticipated stabile slope resulting from the shown dredge elevation. The constructed slope may very based on construction sequencing of the adjacent remedies.
4. Bathymetry surveyed by Lower Duwamish Waterway Group (August 2003).
5. Mean lower low water elevation = MLLW
6. Mean higher high water elevation = MHHW

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ANCHOR QEA

Figure 6g

Preferred Alternative Cross Section G-G'
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